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ORIGINAL ARTICLES.

I.—The Functions of Geology in Education and Practical Life.

By Professor W. W. Watts, M.A., M.Sc., etc., etc., President of the Geological Section.[1]

At the Leeds Meeting of the British Association in 1890, my old friend Professor A. H. Green delivered an address to the Section which has generally been regarded as expressing an opinion adverse to the use of the science of geology as an educational agent. Some of the expressions used by him, if taken alone, certainly seem to bear out this interpretation. For instance, he says: "Geologists are in danger of becoming loose reasoners"; further he says: "I cannot shut my eyes to the fact that when geology is to be used as a means of education there are certain attendant risks that need to be carefully and watchfully guarded against." Then he adds: "Inferences based on such incomplete and shaky foundations must necessarily be largely hypothetical."

Such expressions, falling from an accomplished mathematician and one who was such an eminent field geologist as Professor Green, the author of some of the most trustworthy and most useful of the Geological Survey memoirs, and above all one of the clearest of our teachers and the writer of the best and most eminently practical textbook on physical geology in this or any other language, naturally exercised great influence on contemporary thought. And I should be as unwise as I am certainly rash in endeavouring to controvert them but for the fact that I think he only half believed his own words. He remarks that "to be forewarned is a proverbial safeguard, and those who are alive to a danger will cast about for a means of guarding against it. And there are many ways of neutralising whatever there may be potentially harmful in the use of geology for educational ends."

After thus himself answering what is in reality his main indictment, Professor Green proceeds with the rest of an address

[1] British Association for the Advancement of Science, Southport, Sept. 9–16, 1903. Address to the Geological Section.

crammed full of such valuable hints as could only fall from an experienced and practical teacher, showing how much could be done if the science were only properly taught.

And then he concludes by asking for "that kindly and genial criticism with which the brotherhood of the hammer are wont to welcome attempts to strengthen the corner-stones and widen the domain of the science we love so well."

I think the time has now come to speak with greater confidence, and, although the distant signal stands at danger, to forge ahead slowly but surely, keeping our eyes open for all the risks of the road, with one hand on the brakes and the other on the driving gear, secure at least in the confidence that Nature, unlike man, never switches a down train on to the up track.

Those of us who have been teaching our science for any considerable time have come to realise that there are many reasons why geology should be more widely taught than at present; that there are many types of mind to whom this science appeals as no other one does; and that there are abundant places and frequent circumstances which allow of the teaching of it when other sciences are unsuitable.

To begin with, there is no science in which the materials for elementary teaching are so common, so cheap, and everywhere so accessible. Nor is there any science which touches so quickly the earliest and most elementary interests. It was for this reason that Huxley built his new science of physiography on a geological basis. Hills, plains, valleys, crags, quarries, cuttings, are attractive to every boy and girl, and always rouse intelligent curiosity and frequent inquiry; and although the questions asked are difficult to answer in full, a keen teacher can soon set his children to hunt for fossils or structures which will give them part of the information they seek. Of course the teaching cannot go very far without simple laboratory and museum accommodation, and without a small expenditure on maps and sections; but the former of these requirements can soon be supplied from the chemical laboratory and by the collection of the students themselves, while the latter are every day becoming cheaper and more accessible and useful. The bicycle and the camera, too, are providing new teaching material and methods, while at the same time they are giving new interests. The bicycle has already begun to create a generation to whom relief maps are not an altogether sealed book, and for whom the laws which govern the relief of a country are rapidly finding practical utility; and the camera, at the same time that it quickens the appreciation of natural beauty, must give new interest to each scrap of knowledge as to the causes, whether botanical or geological, to which that beauty is due. And it is this new knowledge which in turn develops the æsthetic sense. *Mente, manu, et malleo* sums up most of what is required in the early stages of learning; but to round off the motto we still require words to express the camera and bicycle.

Another reason is the open-airness of the practice of the science. The delight of the open country comes with intense relief after the classroom, the laboratory, or the workshop. In education generally, and especially in geological education, we have reached the end of the period when

> "All roads lead to Rome
> Or books—the refuge of the destitute."

Of course, I realise fully the vital necessity of laboratory and museum work in the stages of both learning and investigation, and quite freely admit that there is an immense amount of useful work being done and to be done in these institutions alone. But what I think I do right to insist upon is that all work in the laboratory and museum must be mainly preparatory to the field-work which is to follow; every type of geological student must be sent into the field sooner or later, and in most cases the sooner the better. I have generally found that students in the early stages have a great repugnance to the grind of working through countless varieties of minerals, rocks, and fossils; but once they have gone into the field, collected with their own hands, and seen the importance of these things, and the inferences to be drawn from them, for themselves—once indeed they have got keen—they come back willingly, even eagerly, to any amount of hard indoor work.

But it is when they leave ordinary excursion work and start upon regular field training that one really feels them spurt forward. As soon as they begin to realise that surface-features are only the reflex of rock-structure and can be utilised for mapping, that to check their lines and initiate new ones they must search for and find new exposures, and that each observation, while settling perhaps one disputed point, may originate a host of new ones, when, above all, they can be trusted with a certain amount of individual responsibility and given a definite point to settle for themselves, it is then that their progress is most rapid, and is bounded only by their powers of endurance.

I have often watched my students through the various stages of their field training with the deepest interest as a study of the development of character. At first they look upon it merely as a relief from the tedium of the classroom and laboratory, and as a pleasant country excursion. But gradually the fascination of research comes over them, and as they feel their capacity increasing and their grip and insight into the structure of the country deepening, one can see them growing up under one's eyes. They come into the field a rabble of larky boys; they begin to develop into men before they leave it.

And what is true of students is more than ever true of the working geologist. I hold that every geologist, whatever his special branch may be, should spend a portion of every year in the field. Though a petrologist may have specimens sent to him from every variety, even the common ones, in a rock-mass, and have their relations and proportions properly explained to him, it is quite impossible for him

to feel and appreciate these proportions and relationships so well as if he had studied and collected in the field and gained a personal interest in them. Besides this the conclusions drawn in the field are the crystalline and washed residuum, so to speak, left on the mind after the handling of dozens of specimens, weathered and unweathered, and the seeing them in a host of different lights and aspects. The rock is hammered and puzzled over and its relations studied, until some conclusion is arrived at which bears the test of application to all the facts observed in the field.

Again, once a palæontologist is divorced from the field he loses the significance of minute time variations, the proportion of aberrant to normal forms, and the value of naked-eye characteristics which can be 'spotted' in the field. Huxley once asked for a palæontologist who was no geologist; I venture to think we have now had enough of them. What we want above all at the present time is the recognition of such characters as have enabled our field palæontologists to zone by means of the graptolites, the ammonites, and the echinids, so that every rock system we possess may be subdivided with the same minuteness and reliability as the Ordovician, Silurian, and Jurassic systems, and the Chalk.

If this is once done the biological results will take care of themselves, and we may feel perfect confidence that new laws of biological succession and evolution will result from such work, as indeed they are now doing—laws which could never be reached from first principles, but could only come out in the hands of those to whom time and place were the factors by which they were most impressed. It is only by field-work that we shall ever get rid of the confusion which has been inevitable from the supposed existence of such so-called species as *Orthis caligramma*, *Atrypa reticularis*, and *Productus giganteus*.

As for the geological results, it is only necessary to read the excellent and workmanlike Address delivered to this Section at Liverpool in 1896 by Mr. Marr to realise how many problems of succession and structure, of distribution and causation, of ancient geography and modern landscape, are still awaiting solution by the application of minute and exact zonal researches.

On the other hand it goes without saying that the more a field geologist knows of his rocks and fossils the better will his stratigraphical work become; but this is too obvious to require more than stating.

Geology, again, is of value as a recreative science, one which can be enjoyed when cycling, walking, or climbing, even when sailing or travelling by rail. Indeed, it is difficult to find a place in which to treat the confirmed geologist if you wish to make him a 'total abstainer.' There are others than those who must make use of their science in their professions, those in need of a hobby, those interested in natural scenery, veterans who have seen much and now have leisure and means to see more, and those fortunate ones who have not to earn their bread by the sweat of their brain or

brow. Many of these have done and are doing good work for us, and many more would find real pleasure in doing so if only they had been inoculated in those early days when impressions sink deep. Mr. A. S. Reid, who has had much and fruitful experience in teaching, tells me that he has often seen seed planted in barren ground at school spring up and grow and blossom as a country holiday recreation after schooldays, or bear the good fruit of solid research after lying dormant for many years.

We may next look upon geology as an educational medium from quite a different point of view. If more than half the work of the man of science is the collection of fact, and of actual fact as opposed to the result of the personal equation, geology is perhaps the very best training-ground. There are such hosts of facts to be still recorded, so many erroneous observations to be corrected, and so much hope of extending observations on already recorded facts, that there is plenty of work even for the man who can snatch but limited leisure from other pursuits and the one who is a collector of fact and nothing else, as well as those

> "Under whose command
> Is earth and earth's, and in their hand
> Is Nature like an open book."

But in the collection of facts a wise and careful selection is constantly necessary in order to pick out from the multitude those which are of exceptional value and importance in the construction of hypotheses. Nature, it is true, cannot lie; she is a perfectly honest but expert witness, and it takes an astonishing amount of acute cross-examination to elicit the truth, the whole truth, and nothing but the truth.

There is no science which needs such a variety of observations as field geology. When we remember that Sedgwick and Darwin visited Cwm Glas and carried away no recollection of the features which now shout 'glaciation' to everyone who enters the Cwm, it is easy to see how alert must be the eyes and how agile the mind of the man who has to carry a dozen problems in his mind at once, and must be on the look-out for evidence with regard to all of them if he would work out the structure of a difficult country; and who is not only looking out for facts to test his own hypothesis, but wishes to observe so accurately that if his hypothesis gives way even at the eleventh hour his facts are ready to suggest and test its successor. There is no class of men so well up in what may be called observational natural history generally as the practised field geologist, because he never knows at what moment some chance observation—a mound, a spring, a flower, a feature, even a rabbit-hole or a shadow—may be of service to him. Not only should he know his country in its every feature and every aspect, but he must have, and in most cases soon acquires, that remarkable instinct which can only be denoted as an 'eye for a country,' with which generally goes a naturalist's knowledge of its plants and of its birds, beasts, and fishes.

At the present time many educationists are in favour of teaching only the experimental sciences, to the exclusion of those which collect their facts by observation. This attitude may do some good to geology in compelling us to pay more attention to that side of our science which has been better cultivated hitherto in France than in our own country. But whether we think of education as the equipping of a scientific man for his future career or as the training of the mind to encounter the problems of life, we must admit that it would be as wrong to ignore one of the two ways only of collecting fact as it would be to teach deductive reasoning to the exclusion of that by induction. Indeed, this is understating the case, for in the vast majority of the problems which confront us in every-day life the solution can only be reached if an accurate grasp of the facts can be obtained from observation. The training of the mind solely by means of experiments carefully designed to eliminate all confusing and collateral elements savours too much of 'milk for babes' and too little of 'strong meat for men.'

Mr. Teall, in his masterly address to the Geological Society in 1901, pointed out "that the state of advancement of a science must be measured, not by the number of facts collected, but by the number of facts *co-ordinated*." Theory, consistent, comprehensive, tested, verified, is the lifeblood of our science as of any other. It is what history is to politics, what morals are to manners, and what faith is to religion.

It is almost impossible to collect facts at all without carrying a working hypothesis to string them on. It is easy to follow Darwin's advice and speculate freely; the speculation may be right, and if wrong it will be weeded out by new facts and criticism, while the speculative instinct will suggest others. In hypothesis there will always be an ultimate survival of the fittest.

And it is not only easy but absolutely necessary, because in geology, more perhaps than in any other science, hypotheses are like steps in a staircase: each one must be mounted before the next one can be reached; and if you have no intention of coming back again that way, it does not matter if you destroy each step when you have made use of it. Every new hypothesis has something fresh to teach, and nearly all have some element of untruth to be ultimately eliminated. But each one is a stage, and a necessary stage, in progress.

In physics and in chemistry the chief difficulties are those which surround the making of experiments. When these have been successfully overcome the right theory follows naturally, and verification is not usually a very lengthy process. In geology, on the other hand, theory is more quickly arrived at from the numerous facts; but the price is paid in the patience required for testing and the ruthless refusal to strain fact to fit theory. Every hypothesis leads back to facts again and again for verification, extension, and improvement.

Many of the leading conclusions of our science have not yet

become part of the common stock of the knowledge of the world; indeed, they are not even fully realised by many men eminent in their own sciences. The momentum given by Werner and Playfair, Phillips and Jukes, Sedgwick and Lyell, and other pioneers of the fighting science, has died down, and in the interval of hard work, detailed observation, minute subdivision, involved classification, and pedantic nomenclature which has followed, and which I believe to be only the prelude to an epoch of more important generalisation in the immediate future, it has been difficult for an outsider to see the wood for the trees. He has hardly yet realised that facts as vital to the social and economic well-being of the people at large, and conclusions of as great importance in the progress of the science and of as far-reaching consequence in the allied sciences, are being wrung from Nature now as in the past.

"The unimaginable touch of Time," the antiquity of the globe as the abode of life, the absolute proof of the evolution of life given by fossils, the proofs of change and evolution in geography and climate, the antiquity of man, the nature of the earth's interior, the tremendous cumulative effect of small causes, the definite position of deposits of economic value, the rôle played by denudation and earth-movement in the development of landscape, the view of the earth as a living organism with the heyday of its youth, its maturity, and its future old age and death, to mention but a few of our great principles, furnish us with conceptions which cannot fail to quicken the attention and inspire the thought of students of history, geography, and other sciences.

Now that these things are capable of definite proof, that they are of real significance in the cognate sciences, and of actual economic value, above all now that the nineteenth century, the geological century, has closed, that the heroic age is over, that we have passed the stages of scepticism and religious intolerance and reached the stage "when everybody knew it before," it might be expected that a fairly accurate knowledge and appreciation of these principles should form part of the common stock of knowledge, and be a starting-point in the teaching of allied sciences.

Another feature which adds to the attractiveness of geological observations is their immediate usefulness from many points of view. The relief and outline of any area is as closely related to its rocky framework as the form of a human being is related to his skeleton and muscles. The geological surveyor recognises how every rise and fall is the direct reflex of some corresponding difference in the underlying rocks; he seeks to observe and explain the ordinary as well as anomalous ground features, every one of which conveys some meaning to him.

A geological basis for the classification and grouping of surface-features is the only one which is likely to be satisfactory in the end, because it is the only one founded on a definite natural principle, the relation of cause to effect. It is not without good reason that the topographic and geological surveys of the United States are

combined under one management, and nowhere else are the topographic results more accurate and satisfactory. Landscape is traced back to its ultimate source, and consequently sketched in with more feeling for the country and greater accuracy of knowledge than would otherwise be possible. Geologists were among the first to cry out for increasing accuracy and detail in our Government maps, and they have consistently made the utmost use of the best of these maps as fast as they appeared. With the publication of each type of map, hachured, contoured, six-inch, twenty-five inch, the value and accuracy of geological mapping have advanced step by step. Wherever the topography is better delineated than usual the facilities are greater for accurate geological work, and the best geological maps, and those in greatest demand, are always those based on the most minute and detailed topographic work. On the other hand, geologists are training up a class of men who can read and interpret the inner meaning of these maps, and make the fullest use of the splendid facilities given by the minute accuracy of the ordnance work.

Lord Roberts has recently complained that the cadets at Woolwich are unable to read and interpret maps, and he "strongly advised them to set about improving themselves in this respect, or they would find themselves heavily handicapped in the future." I believe that the only training in this subject before entering the Royal Military Academy and the Royal Military College has been that given to those candidates who have taken up geology for their entrance examination. By encouraging these students to study and draw maps and sections of their own districts, and to explain and draw sections across geological maps generally, thus accounting for surface-features, the examiners have compelled this small group of candidates to see deeper into a map than ordinary people. If only this training had been encouraged and advanced and made use of later, the Commander-in-Chief would have had no cause of complaint with regard to these particular men. Looking at a map is one thing; working at it, seeing into it, and getting out of it what is wanted from the vast mass of information crammed into it, is quite another; and geology is the very best and perhaps the only means of compelling such a close study of maps as to enable students to seize upon the salient features of a country from a map as quickly and accurately as if the country itself were spread out before them. The geologist is compelled to work out and classify for himself the features he observes on his maps, such as scarps and terraces, crags and waterfalls, streams and gorges, passes and ridges; the run of the roads, canals, and railways, the nature and accessibility of the coast, and all those features which make the difference between an easy-going and a difficult country. When he has worked his way over a map in this fashion that map becomes to him a real and telling picture of the country itself.

Experience, bitter experience, in South Africa has shown the necessity not only for good maps and map-reading, but for that which is the most priceless possession alike of the best field geologists

and of the best strategists, a good 'eye for a country.' It has been said that the Boer war was a geographical war; but it was even more, and, especially in its later stages, a topographic war. Again and again the Boers aroused our astonishment and admiration by the way in which their topographic knowledge and instinct enabled them to fight, to defend themselves, and to secure their retreat by the most consummate ability in utilising the natural features of their country. This was due to two things. In the first place they took care to have with them in each part of the country the men who knew that particular district best in every detail and in every aspect. But in the second place there can be no doubt that they made the utmost use of that hunter-craft by which the majority of them could take in at a glance the character of a country, even a new one, as a whole, guided by certain unconscious principles which each man absorbed as part of his country life and hunter's training. They possessed, and had of necessity cultivated to a very high degree, an 'eye for a country.'

Now the study of the geology of any district, and especially the geological mapping of it, goes a long way towards giving and educating the very kind of eye for a country which is required, partly by reason of the practice in observation and interpretation which it is continuously giving, and partly because it deliberately supplies the very kinds of classification and the principles of form which a hunter-people have unconsciously built up from their outdoor experience.

Any geologist who thinks of the Weald, the wolds and downs of Eastern England, the scarps and terraces of the Pennine, the buried mountain structure of the Midlands, even the complicated mountain-types of Lakeland and Wales, will remember how often his general knowledge of the rock-structure of the region has helped him as a guide to the topography; and as his geological knowledge of the area has increased he will recall how easy it has become to carry the most complicated topography in his mind, or to revive his recollection of it from a glance at the map, because the geological structure, the anatomy, is present in his mind throughout, and the outside form is the inevitable consequence of that structure. Indeed, the reading of a good geological map to the geologist is like the reading of score by a musician.

Surely it would be most unwise if the Committee on Military Education were to cut out of their curriculum the one subject which has exercised and educated this faculty, and one which is at the same time doing a great deal to counteract that degeneration of observing faculties inseparable from a town life. Some cadets at least ought to be chosen from amongst those men who have been trained by this method to see quickly and accurately into the topographic character and possibilities of a country, and provision should be made for educating their faculties further until they become of genuine strategic value.

Then I believe it would be correct to say that no class of men get to know their own country with anything like the minuteness

and accuracy of the geological surveyor. The mere topographer simply transfers his impressions on the spot as quickly as may be to paper, and has no further concern with them. The geologist must keep them stored in his mind, watching the variation and development of each feature from point to point for his own purposes. He must traverse every inch of his ground, he must know where he can climb each mountain and ford every brook, where there are quarries or roads, springs or flats; what can be seen from every point of view, how the habitability or habitations vary from point to point; in short, he must become a veritable walking map of his own district. Why not scatter such men in every quarter of the globe, particularly where any trouble is likely to arise? They are cheap enough, they will waste no time, and they will be so glad of the chance for research that they will not be hard to satisfy in the matter of pay and equipment. Thus you will acquire a corps of guides, ready wherever and whenever they are wanted; and when trouble arises they may do a great deal by means of their minute knowledge of topography to save millions of money and thousands of lives, and to prevent the irritating recurrence of the kind of disaster with which we have become sadly familiar within the last five years.

In dealing with the relationship of geology to geography, geologists are frequently charged with claiming too much. On this point at least, however, there can be no difference of opinion, that the majority of geological surveyors and unofficial investigators have kept their eyes open to this relationship, and have often contributed new explanations to old problems. They have been compelled to observe, and often to explain, surface-features before making use of them in their own mapping, and in doing so have often hit upon new principles. It is hardly needful to mention such examples as Ramsay's great conception of plains of marine denudation, Whitaker's convincing memoir on subaërial denudation, Jukes's explanation of the laws of river adjustment, Gilbert's scientific essay on erosion, Heim's demonstration of the share taken by earth-movement in the modelling of landscape features, and the exceedingly valuable proofs of the relation of human settlement and movement to underground structure, worked out with such skill and diligence by Topley in his masterly memoir on the Weald—the jumping-off place, if I may so term it, of the new geography.

No one is more pleased than geologists that geographers have ceased to draw their knowledge of causation solely from history, and that they have turned their attention to the dependence and reaction of mankind on nature as well. But while hoping that geographers will continue to study, so far as they logically can, the relationshipof plants, animals, and mankind to the solid framework of the globe on which they live, we must draw the line at the invention of new geological hypotheses to explain geographic difficulties on no better evidence than that furnished by the difficulties themselves; on the other hand, we must insist that each

new geological principle must take its place amongst geographic explanations as soon as it is freely admitted to be based on a sound substratum of fact.

I must confine myself to a few instances of what I mean. Mr. Marr's geological work on the origin of lake-basins has led to some remarkable and unexpected conclusions with regard to the history and origin of the drainage of the Lake district. Some of the very difficult questions raised by the physical geography of the North Riding of Yorkshire have received a new explanation from the researches of Mr. Percy F. Kendall and Mr. A. R. Dwerryhouse, an explanation which is the outcome of purely geological methods of observation of geological materials. Again, the simple geological interpretation of a well-known unconformity between Archæan and Triassic rocks has made it extremely probable that many of the present landscapes, not only in the Midlands but elsewhere, may be really fossil landscapes, of great antiquity and due to causes quite different from those in operation there at the present day. In mountain regions, too, it can only be by geological observation that we shall ever determine what has been the precise direct share of earth-movement in the production of surface-relief. Such examples seem to indicate that many of the principles must be of geological origin but of geographic application.

While geology has been of direct scientific utility in topography and geography there is another domain, that of economic geology, which is entirely its own. The application of geology extends to every industry and occupation which has to do with our connection with the earth on which we live. Agriculture, engineering, the obtaining of the useful and precious metals, chemical substances, building materials, and road metals, sanitary science, the winning and working of coal, iron, oil, gas, and water, all these and many more pursuits are carried on the better if founded on a knowledge of the structure of the earth's crust. Indeed, a geological map of this country, showing rocks, solid and superficial, of which no economic use could be made, would be nearly blank. Yet so much has this side of the science been neglected of recent years that our only comprehensive textbooks on it are altogether out of date.

But in teaching geology as a technical science, or rather as one with technological applications, one of the greatest difficulties before us is to steer between two opposing schools, the so-called theoretical school and the practical school.

There are those who say there is but one geology, the theoretical, and that a thorough knowledge of this must be obtained by all those who intend to apply the science. Others think that this is too much to ask—that the time available is not sufficient—and that it is only necessary to teach so much of the subject as is obviously germane to the question in hand.

The best course appears to me to be the middle one between the two extremes. If the engineer or miner, the water-finder or quarryman, has no knowledge of principles, but only of such

facts as appear to be required in the present position of his profession, he will be incapable of making any improvement in his methods, so far as they depend upon geology. If, on the other hand, he is a purely theoretical man without a detailed practical and working acquaintance with the facts which specially concern him, he will be put down by his colleagues as unpractical; he will have to learn the facts as quickly as he can, and buy his experience in the dearest market.

It seems to me that there is certain common ground which must be acquired by all types of professional men. The general petrographic character of the common rocks, enough of their mode of origin to aid the memory, the principle of order and age in the stratified rocks, the use of fossils and superposition as tests of age, the nature of unconformities, the relation of structure to the form of the ground, the occurrence of folds and faults, and above all the reading of maps and sections, and sufficient field-work to give confidence in the representation of facts on maps—these things are required by everybody who makes any use of geology in his daily life.

But when so much has been acquired it should be possible to separate out the students for more special treatment. The coal-miner will require especially a full knowledge of the coal-bearing systems, not in our own islands merely, but all over the world; a special acquaintance with the effects of folds and faults, and an advanced training in the maps and sections of coal-bearing areas. The vein-miner should be well up in faulting and all the geometrical problems associated with it, and he should have an exhaustive acquaintance with the vein and metalliferous minerals.

The water engineer needs to know especially well the porous and impervious rock types, the texture and composition of these rocks, the nature of their cements and joints, and the distribution of water-levels in them. Further, he must know what there is to be known on the problems of permeability and absorption, the relation of rain to supply, the changes undergone by water and the paths taken by it on its route underground, and the varying nature of rocks in depth. He must also realise the effects of folds and faults on drainage areas and on underground watercourses, the special qualities of water-yielding rocks, of those forming the foundation of reservoir sites, and those suitable for the construction of dams.

The sanitary engineer will need to be acquainted with the same range of special knowledge as the water engineer, but will naturally be more interested in getting rid of surface water without contaminating it more than he can help than in obtaining it; he will also need a more detailed acquaintance with superficial deposits than any other class of professional men.

The quarryman and architect ought to know the rocks both macroscopically and microscopically. in their chemical and mineralogical character, their grains and their cements. But he ought to be well acquainted with the laws of bedding, jointing, and cleavage, with questions of outcrop and underground extent, and all those

other characters which make the difference between good and bad stone, or between one desirable and undesirable in the particular circumstances in which a building is to be erected. Further, he should make a particular study of the action of weight and weather on the rocks which he employs.

The road engineer and surveyor, now that it has been discovered that it is cheaper and better to use the best and most lasting road-metal instead of any that happens to be at hand, requires to have an extensive acquaintance with our igneous and other durable rocks. He needs, however, not only petrographic and chemical knowledge, but also a type of information not at present accessible in England, the relative value of these rocks in resisting the wear and tear of traffic, the cementing power of the worn material, and the surface characters of roads made from them, in order that he may in each case select the stone which in his particular circumstances gives the best value for money. It would surely pay the County Councils to follow, with modifications, the example of the French and Americans, and carry out a deliberate and well-planned series of experiments on all the material accessible to them in their respective districts.

The teaching of the application of geology should therefore take some such form as the following:—First, the principles should be thoroughly taught with the use for the most part of examples drawn from the economic side; thus cementing might be illustrated on the side of water percolation, jointing from the making of mine roads and from quarry sites, faulting from effects on coal outcrops and veins, unconformity from its significance to the coal-miner; while in teaching the sequence of stratified rocks the systems and stages could be mainly individualised by their economic characters. When this is done the class must be divided into groups, each paying special attention to the points which are of essential importance to them.

The teaching at all stages should be practical and, so far as can be, experimental, and in all cases where possible a certain amount of field-work should be attempted. For the field, after all, is the laboratory of the geologist, where he can observe experiments being made on a gigantic scale under his eyes.

The aim of the teaching should be to give to students the equipment necessary to deal with the chief geological problems that they will meet with in their varied professions; it should show them where to go for maps, memoirs, or descriptions of the areas with which they are dealing; and in cases of great difficulty should enable them to see where further geological assistance is required, and to weigh and balance the expert evidence given them against the economic and other factors of the problem before them.

From men educated thus geology has the right to expect a valuable return. There is a vast amount of knowledge on economic subjects in existence but not readily accessible. It has been obtained by experts, and after being used is locked up or lost. And yet it is the very kind of knowledge which is wanted to extend

our principles further into the economic side of the subject. So well is this recognised that many geologists are attracted to economic work mainly because of the wide range of new facts that they can only thus become acquainted with. It is possible to make use of many of these facts for scientific induction without in any way betraying confidence or revealing the source from which they are obtained; and even if they cannot be used directly they are often of great service in giving moral support, or the contrary, to working hypotheses founded on other evidence.

The knowledge of our mineral resources is of such vital consequence to ourselves and to our present and future welfare as a nation, and yet it is a matter of so much popular misconception, that I feel bound to dwell on this subject a little longer. To anyone who studies the growth and distribution of population in any important modern State the facts and reasons become as clear as day.

It is easy to construct maps showing at a glance the density of population in any country. Perhaps the most effective way to do so is to draw a series of isodemic lines, and to gradually increase the depth of tint within them as the number of people per square mile increases until absolute blackness represents, say, over 2,000 people per square mile. Such maps are the best means of displaying the geography of the available sources of energy in a country at any particular period. Population maps of England and Wales in the early part of the eighteenth century would be pale in tint with a few rather darker patches, and would show a distribution dependent solely upon food as a source of energy working through the medium of mankind and animals. Such maps would be purely agricultural and maricultural, dependent upon the harvests of the land and sea. Maps made at a later period would show a new concentration round other sources of energy, particularly wind and water, but would not be perceptibly darker in tint as a whole; for although we are apt to think that we have in this country too much wind and water, they are not in such a form that we can extract any appreciable supply of energy directly from them.

But maps representing the present population, while still mainly energy maps, at once bring out the fact that our leading source of energy is now *coal*, and no longer food, wind, or water. The new concentrations, marked now by patches and bands of deepest black, have shifted away from the agricultural regions and settled upon and around the coalfields. The map has now become geological.

The difference between the old and the new map is, however, not only in kind; it is even more remarkable in degree. The population is everywhere much denser. Not only are the mining and manufacturing areas on the new map more than eight times as densely populated as any areas on the older map, not only is the average population five times greater throughout the country, but the lightest spot in the new map is nearly as dark as the darkest spot on the old one. The sparsest population at the present day is as

thick on the ground as it was in the densest spots indicated on the older map, while at the same time the standards of wages, living, and comfort, instead of decreasing, have increased.

The discovery of this new source of energy, coal, immediately gave employment to a much larger number of people; it paid for their food and provided the means of transporting it from the uttermost parts of the earth. Under agricultural conditions the map shows that the population attained a given maximum density, and no further increase was possible, the density being regulated by the food supply raised on the surface of the land. Our dwelling-house was but one story high. Under industrial conditions our mineral resources can support five times the number. Our dwelling-house is of five stories—one above ground and four below it.

At the same time the type of distribution is altered. The agricultural areas are now covered by a relatively scanty population and the dense areas are situated on or near to the coal and iron fields, the regions yielding other metals, those suitable for industries which consume large supplies of fuel, and a host of new distributing centres, nodal points on the new lines of traffic, either inside the country or on its margins where the great routes of ocean transport converge, or where the sea penetrates far in towards the industrial regions.

It has been the good fortune of this country to be the first to realise, and with characteristic energy to take advantage of, the new possibilities for development opened up by the discovery and utilisation of its mineral wealth. We were exceedingly fortunate in having so much of this wealth at hand, easy to get and work from geological considerations, cheap to transport and export from geographical considerations. So we were able to pay cash for the products of the whole world, to handle, manufacture, and transport them, and thus to become the traders and carriers of the world.

But other nations are waking up. We have no monopoly of underground wealth, and day by day we are feeling the competition of their awakening strength. Can we carry on the struggle and maintain the lead we have gained?

In answering this question there are three great considerations to keep in mind. First, our own mineral wealth is unexhausted; secondly, that of our colonies is as yet almost untouched; and thirdly, there are still many uncolonised areas left in the world.

The very plenty of our coal and iron, and the ease of extracting it, has been an economic danger. There has been waste in exploration because of ignorance of the structure and position of the coal-yielding rocks; waste in extraction because of defective appliances, of the working only of the best-paying seams and areas, of the water difficulty, and the want of well-kept plans and records of areas worked and unworked; waste in employment because of the low efficiency of the machinery which turns this energy into work. With all this waste our coalfields have hardly yielded a miserable *one* per cent. of the energy which the coal actually possesses when *in situ*.

Engineers and miners are trying to diminish two of these sources of waste, and geology has done something to reduce that of exploration. This has been done by detailed mapping and study, so that we now know the areas covered by the coal-seams, their varying thickness, the 'wants,' folds, and faults by which they are traversed, and all that great group of characters designated as the geological structure of the coalfields. It could not have been accomplished unless unproductive as well as productive areas had been studied, the margins of the fields mapped as well as their interiors, and unless the geological principles wrested from all sorts of rocks and regions had been available for application to the coal districts in question. We no longer imagine every grey shale to be an index of coal; we are not frightened by every roll or fault we meet with underground; nor do we, as in the past, throw away vast sums of money in sinking for coal in Cambrian or Silurian rocks.

We cannot afford, hard bitten as we are in the rough school of experience and with our increased knowledge, to make all the old mistakes over again, and yet we are on the very eve of doing it. Up to the present it is our visible coalfields that we have been working, and we have got to know their extent and character fairly well. But so much coal has now been raised, so much wasted in extraction, and so many areas rendered dangerous or impossible to work, that we cannot shut our eyes to the grave fact that these visible fields are rapidly approaching exhaustion. The Government have done well to take stock again of our coal supply, and to make a really serious attempt by means of a Royal Commission to gauge its extent and duration; and we all look forward to that Commission to direct attention to this serious waste, and to the possibility of better economy which will result from the fuller application of scientific method to exploration, working, and employment.

But we still have an area of concealed coalfields left, possibly at least as large and productive as those already explored and as full of hope for increased industrial development. It is to these we must now turn attention with a view of obtaining from them the maximum amount possible of the energy that they contain. The same problems which beset the earlier explorers of the visible coalfields will again be present with us in our new task, and there will be in addition a host of new ones, even more difficult and costly, to solve. In spite of this the task will have to be undertaken, and we must not rest until we have as good a knowledge of the concealed coalfields as we have of those at the surface. This knowledge will have to be obtained in the old way by geological surveying and mapping, and by the co-ordination of all the observations available in the productive rocks themselves and in those associated with them, whether made in the course of geological study or in mining and exploration. But now the work will have to be done at a depth of thousands instead of hundreds of feet, and under a thick cover of newer strata resting unconformably on those we wish to pierce and work. When we get under the unconformable cover we meet the same geology and the same laws of stratigraphy and

structure as in more superficial deposits, but accurate induction is rendered increasingly difficult by the paucity of exposures and the small number of facts available owing to the great expense of deep boring. How precious, then, becomes every scrap of information obtained from sinkings and borings, not only where success is met with, but where it is not; and how little short of criminal is it that there should be the probability that much of this information is being and will be irretrievably lost!

Mr. Harmer pointed out in a paper to this Section in 1895 that under present conditions there was an automatic check on all explorations of this kind. The only person who can carry it out is the landowner. If he fails he loses his money and does not even secure the sympathy of his neighbours. If he succeeds his neighbours stand to gain as much as he does without sharing in the expense. The successful explorer naturally conceals the information he has acquired, because he has had to pay so heavily for it that he cannot afford to put his neighbours in as good a position as himself and make them his rivals as well; while the unsuccessful man is only too glad to forget as soon as possible all about his unfortunate venture. And yet in work of this kind failure is second only to success in the value of the information it gives as to the underground structure which it is so necessary to have if deep mining is to become a real addition to the resources of the country.

Systematic and detailed exploration, guided by scientific principles, and advancing from the known to the unknown, ought to be our next move forward: a method of exploration which shall benefit the nation as well as the individual, a careful record of everything done, a body of men who shall interpret and map the facts as they are acquired and draw conclusions with regard to structure and position from them—in short, a Geological Survey which shall do as much for Hypogean geology as existing surveys have done for Epigean geology, is now our crying need. Unless something of this sort is done, and done in a systematic and masterful manner, we run a great risk of frittering away the most important of our national resources left to us, of destroying confidence, of wasting time and money at a most precious and critical period of our history, and of slipping downhill at a time when our equipment and resources are ready to enable us to stride forward.

Even supposing the scheme outlined by Mr. Harmer cannot be carried out in its complete form, a great deal will be done if mining engineers can receive a sufficient geological training to enable them to realise the significance of these underground problems, so that they can recognise when any exploration they are carrying out inside their own area is likely to be of far-reaching geological and economic significance outside the immediate district in which they are personally and immediately concerned.

Turning to our colonies, it is true that in many of them much is being done by competent surveys to attain a knowledge of mineral resources, but this work should be pushed forward more rapidly, with greater strength and larger staffs, and above all it should not

be limited to areas that happen to be of known economic value just at the present moment. It is almost a truism that the scientific principle of to-day is the economic instrument of to-morrow, and it will be a good investment to enlarge the bounds of geological theory, trusting to the inevitable result that every new principle and fact discovered will soon find its economic application. Further, it is necessary that we should obtain as soon as possible a better knowledge of the mineral resources of the smaller and thinly inhabited colonies, protectorates, and spheres of influence. This is one of the things which would conduce to the more rapid and effective occupation of these areas.

With regard to areas not at present British colonies, it seems to me that no great harm would be done by obtaining, not in any obtrusive way, some general knowledge of the mineral resources of likely areas. This at least seems to be what other nations find it worth their while to do, and then, when the opportunity of selection arises, they are able to choose such regions as will most rapidly fill up and soonest yield a return for the private or public capital invested in them.

To sum up, I consider that the time has come when geologists should make a firm and consistent stand for the teaching of their science in schools, technical colleges, and universities. Such an extension of teaching will of course need the expenditure of time and money; but England is at last beginning to wake up to the belief, now an axiom in Germany and America, that one of the best investments of money that can be made by the pious benefactor or by the State is that laid up at compound interest, "where neither rust nor moth doth corrupt," in the brains of its young men.

This knowledge has been an asset of monetary value to hosts of individuals who have made their great wealth by the utilisation of our mineral resources, and to our country, which owes its high position among the nations to the power and importance given to it by its coal and iron. It is surely good advice to individuals and to the State to ask them to reinvest some of their savings in the business which has already given such excellent returns, so that they and we may not be losers through our lack of knowledge of those sources of energy which have made us what we are, and are capable of keeping for many years the position they have won for us.

And in our present revival of education it would be well that its rightful position should be given to a science which is useful in training and exercising the faculty of observation and the power of reasoning, which conduces to the open-air life and to the appreciation of the beautiful in nature, which places its services at the disposal of the allied sciences of topography and geography, which is the handmaid of many of the useful arts, and which brings about a better knowledge and appreciation of the life and growth of that planet which we inhabit for a while, and wish to hand on to our descendants as little impaired in vitality and energy as is consistent with the economic use of our own life-interest in it.

Memorial Tablet erected to

PROFESSOR HENRY ALLEYNE NICHOLSON,

M.D., D.Sc., F.R.S., F.G.S. &c., &c.,

In the University of Aberdeen: 1st August, 1903.

II.—Memorial to Henry Alleyne Nicholson, M.D., D.Sc., F.R.S.

(PLATE XXI.)

THE recently erected Memorial to the late Professor Henry Alleyne Nicholson, F.R.S., of Aberdeen, raised by subscription among his friends, deserves a record in the pages of this journal, to which he was for many years a frequent contributor (see Obituary of Nicholson, Geol. Mag., 1899, pp. 138–144, with a portrait, Plate IV).

Professor Charles Lapworth, LL.D., F.R.S., of the University of Birmingham; Mr. John E. Marr, M.A., F.R.S., St. John's College, Cambridge; Dr. Henry Woodward, F.R.S., late of the British Museum (Nat. Hist.); and Professor J. Arthur Thomson, M.A., who succeeded Nicholson as Regius Professor of Natural History in the University of Aberdeen, with very many others, decided to commemorate Nicholson's lifework by some simple yet permanent record; and after consultation with the University authorities it was decided that the memorial should take the form of a Tablet similar to that erected in Aberdeen to the memory of Macgillivray.

The preparation of a design was entrusted to Miss Alice B. Woodward, and the execution to the well-known artists in metal, Messrs. Omar Ramsden & Alwyn C. E. Carr, of Albert Studios, Albert Bridge Road, London, S.W.

The Nicholson Memorial Tablet (which measures 3 feet 8 inches by 2 feet 11 inches) is executed in hand-beaten and repoussé brass, mounted upon a stout framing of oak, and is a good example of the effort now being made to improve the artistic quality of such work, and render it more worthy of its object than the ordinary hurried modern machine-produced metal-work.

The principal motif of the design is a boldly conceived and modelled portrait medallion of Nicholson in 'John Knox' cap and gown, with an inscription setting forth his name and degrees, worked into the design after the manner of the delightful medals produced during the time of the Early Italian Renaissance, a treatment of the portrait-head which has never been surpassed. Beneath this is a square mass of lettering giving an epitome in ten lines of his career, with dates. The following is the full inscription :—

"HENRY ALLEYNE NICHOLSON, M.D., D.Sc., F.R.S.
BORN AT PENRITH SEPT. 1844.
DIED AT ABERDEEN JAN. 1899.
PROFESSOR OF NATURAL HISTORY:
TORONTO, 1871. DURHAM, 1874.
ST. ANDREWS, 1875. ABERDEEN, 1882–99.
SWINEY LECTURER 1877–96.
A SKILLED GEOLOGIST:
AN UNTIRING INVESTIGATOR:
EMINENT AS A TEACHER,
BELOVED AS A FRIEND."

At either side, surmounted by two small Brachiopods of the genus *Orthis*, is a harmonious and elegant band of ornaments, composed of various natural forms of Graptolites gracefully and artistically interwoven, showing how a difficult problem in symbolical ornamentation can be overcome if properly approached with the necessary skill and power of design.

Above the head is a panel representing in low relief the wide expanse of the Cumberland mountains about Penrith, Nicholson's birthplace, and among which for so many years he laboured geologically, with the appropriate inscription "Levavi oculos meos in montes."[1]

Beneath the square inscription is a rich band of ornament, formed by the calices of the beautiful Silurian coral *Omphyma subturbinata*, and the inscription—

"He did a day's work and a man's work."[2]

At the lower corners are placed two Trilobites (*Phacops caudatus* and *Calymene Blumenbachii*) artistically worked out from specimens in repoussé brass, which form most valuable decorative bosses.

The particular idea which the artist had in view, and has successfully realised in the tablet, was to make it expressive of Nicholson's lifework and interests.

The work has been executed with great care and attention to detail, and shows the impression of the tool which is the natural result of hand-labour, and is free from the pockmarked appearance of many modern works in metal in which the hammer marks are applied, after the work is finished, by other than the legitimate hand-processes which, being an affectation, are as far from having any artistic merit as the highly polished machine-made product. The colour of the work is a natural oxidized brass, which harmonizes in a very restful manner with the oak slab upon which it is mounted, and being filled with lead at the back is as permanent as cast bronze, but still retains the lightness of hand-beaten work.

Professor J. Arthur Thomson, who acted with Mr. J. E. Marr in arranging for the Nicholson Memorial, has been untiring in his exertions to see this work carried out satisfactorily, and has rendered most valuable assistance to the artists throughout.

It is proposed that the Memorial Tablet, at present temporarily placed in the Natural History Museum in Marischal College, should find a permanent and prominent position in the new Geological Museum which is included in the extension of the University buildings now in progress.

The Memorial Tablet was handed over to the custody of the University of Aberdeen on Graduation Day, July 24th; it was received by the Very Rev. Principal Marshall Lang, D.D., and some of Nicholson's old colleagues paid eloquent tributes to his memory.

H. W.

[1] "I will lift up mine eyes unto the hills" (Ps. cxxi. 1).
[2] Suggested by Professor Lapworth.

III.—Fossiliferous Oldhaven Beds at Ipswich.

By Henry Bassett, Jun., B.Sc.

In the "Geology of the Country around Ipswich, Hadleigh, and Felixstowe"[1] Mr. Whitaker drew attention to the probable existence of Oldhaven Beds at Ipswich. On p. 11 he gives particulars of a section in Stoke brickyard. Below the London Clay at this spot occurred fine buff sand separated from the Clay by a thin pebble-bed containing fragments of shells. The buff sand was doubtfully referred to the Oldhaven Beds, while it was thought that the pebble-bed should also be included with these rather than regarded as a basement-bed of the London Clay. Below this doubtful Oldhaven sand occurred sands and mottled clays of the Reading Series. It was shown in the memoir that this pebble-bed occurred over a great part of this district with an outcrop along the valleys of the Gipping and the Brett. As a rule it rests on sands referred to the Reading Series, and is classed by Mr. Whitaker sometimes as basement-bed of the London Clay and occasionally as Oldhaven Beds.

Recently in Ipswich I came across a very clear section of these beds in one of the brickfields, and as they here show a rather unusual facies it seems worth while to draw attention to the section, especially as the beds contain many fossils at one spot. The section occurs on the north side of Messrs. Bolton & Laughlin's brickfield between the Norwich and Henley Roads. The brickfield is situated almost due north of Brook's Hall, and about 100 yards south of the railway line, but apparently at the time of the Geological Survey there was no brickfield at this spot; the pebble-bed, however, was shown in another pit (which still exists) a little further westward, and was included in the basement-bed of the London Clay by Mr. Whitaker. About 20 feet of London Clay are shown in Messrs. Bolton & Laughlin's pit, where it is overlain by Middle Glacial sands and gravel, with Chalky Boulder-clay above this a little way off. The London Clay is everywhere underlain by false-bedded, pale yellow sand, upon which, in many parts of the brickfield, the lower part of the clay rests directly; as a rule, however, there is a thin pebble-bed between the clay and the sand. As has been already mentioned, this pebble-bed occurs in many places round Ipswich, and in composition is exactly like the similar beds found near London, that is to say, it is composed almost entirely of small well-rounded black flint pebbles in a sandy matrix—a subangular pebble being only occasionally found.[2] However, at the spot I have mentioned it is found that the pebble-bed, which is there about a foot thick, has entirely changed its character, being composed of pebbles of various rocks, very few of which are well rounded. A large

[1] Mem. Geol. Survey: Explanation of Quarter-Sheets 48 N.W. and N.E., 1885.

[2] On p. 24 of the memoir already referred to Mr. Whitaker mentions finding a subangular flint in this pebble bed in a brickfield near Whitton.

number of the pebbles are composed of hard clay, while there are others of sandstone and slightly rolled flints. The typical black well-worn flints characteristic of this horizon of the Eocene beds here form only a small proportion of the total. Another striking feature about the bed is that it is crowded with shells. These shells are quite perfect, but very fragile, and it is almost impossible to get them out whole. Sharks' teeth are also fairly abundant. The following shells and teeth have been obtained, and most of them were very kindly identified for me by Mr. E. T. Newton, F.R.S. The shells were so fragmentary that it was practically impossible to assign more than a generic name; it was much easier, in fact, to name them before removing them from the pebble-bed.

Astarte (*tenera*? and *rugata*?).
Cardium.
Corbula.
Cyrena.
Cytherea (*orbicularis*?).
Ostrea (only one rolled fragment found).
Pectunculus.
Aporrhais.
Natica.
Teeth of—
Odontaspis elegans, Ag.
Odontaspis (*cuspidata*?), Ag.
Lamna Vincenti, Winkler.
Teleostean fish vertebra.

Shells belonging to the genera *Astarte* and *Corbula* were much the commonest. The clay pebbles occurring in this bed have, I think, undoubtedly been derived from local beds of the Reading Series, for the clay is in every way similar in appearance to that occurring in the Reading Beds above the Chalk in the well-known section at Bramford, about two miles off. The sandstone pebbles have also very probably been derived from other beds of the same series. As the pebble-bed is traced westwards from the part of the section at which the shells occur, it is found that first of all it loses its abnormal character and is composed almost entirely of small black flint pebbles. A little further on, however, when about 40 yards from the starting-point, it has become still more unusual in its character, being now represented by a bed about 6 feet thick, composed almost entirely of clay pebbles of various sizes, from 1 to 12 inches in diameter. The clay pebbles lie with the original bedding-planes of the Clay at all angles to the somewhat indistinct bedding of the pebble-bed, and, as before, they have doubtless been derived from local Reading Clay beds. A few Chalk fragments also occur, and also a considerable amount of race.

The clay pebble-bed in some directions insensibly shades into the underlying sands, upon which it rests in an exceedingly irregular manner, and into which in some places it suddenly scoops down for a foot or two. The bedding approximately follows this irregular base-line. The normal type of flint pebble-bed, however, although it varies somewhat in thickness (from 0 to 1 foot), only does so gradually, and does not exhibit the very uneven base of the clay pebble-bed.

In a few parts of the pit there is a thin bed (a few inches thick) of rolled black flint pebbles between the clay pebble-bed and the overlying London Clay. This was well seen at the part of the section where the shells occurred, but unfortunately this part of

the pit is now being filled up. It seems as though the two types of pebble-bed shaded more or less into one another, and, although occasionally the two occur one above the other, this is not usual.

The following represents a section at a spot where both types occurred together :—

		Feet.
London Clay.	Brown and grey bedded clay (with pyrites and selenite) ...	14
Basement-Bed of London Clay.	Brown bedded loam with two thin dark clay bands containing pyritised fragments of wood, etc.	3
Oldhaven Beds.	Bed of well-rolled black flint pebbles	0½
	Clay pebble-bed	2
Reading Beds.	False-bedded, pale yellow sand, with occasional small pebbles of clay and race near the top ... ... (seen)	6

Another point of interest is that the shells only occur in those parts of the pebble-bed which contain a considerable amount of clay pebbles, only sharks' teeth occurring in the parts consisting entirely of flint pebbles. This, no doubt, is due to the clay having protected the shells to a certain extent from the solvent action of percolating water.

On glancing at the list of shells from this spot it will be seen that nearly all of them belong to marine genera. This, of course, might be considered a good reason for including these pebble-beds in the basement-bed of the London Clay rather than classing them as Oldhaven Beds. In spite of this, however, it seems to me that the beds under discussion have as much right to be considered as belonging to the Oldhaven Series as the beds in many other places whose right is hardly questioned. In many cases the Oldhaven Beds differ from the overlying London Clay and the Woolwich and Reading Beds below chiefly in their lithological characters, which indicate strong currents and disturbed conditions. The assemblage of marine and fresh-water shells is by no means always found. Take, for example, the case of the Oldhaven Beds at Sundridge Park or Elmstead Cutting, Kent. Fossils are exceedingly abundant there, the most common being species of the genera *Ostrea*, *Pectunculus*, and *Corbula*; fresh-water shells, however, form only a very small percentage of the total, and they, moreover, nearly always are very much worn and have the appearance of drifted shells, while the marine shells are not worn at all. The beds here also show well two other characteristics of the Oldhaven Beds, namely, the sudden way in which they thicken out and the erosion of the underlying Woolwich and Reading Beds. Thus, in a distance of about a quarter of a mile, the Oldhaven Beds at Sundridge Park tunnel thicken from about a couple of feet to nearly 40 feet, at the same time scooping down into the underlying beds, so that finally they rest on Thanet Sand.[1] Both these features are seen, though on a smaller scale, in the corresponding beds at Ipswich, the sudden variations in the thickness of the beds having already been mentioned, while the erosion of the Reading Beds can be inferred from the occurrence of the clay pebbles.

The occurrence of the bed of clay pebbles containing large

[1] See Whitaker, "Geology of London and Part of the Thames Valley," vol. i.

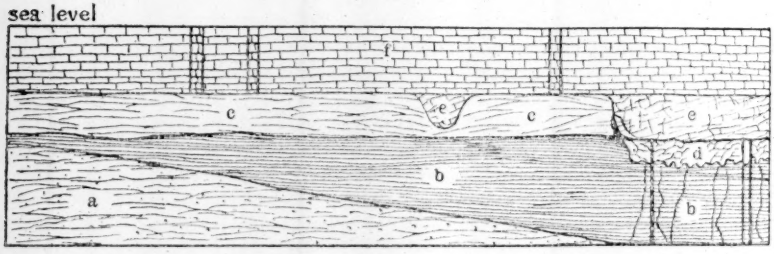
numbers of subangular flint and sandstone pebbles is very unusual and has not, I believe, been noticed before, and is no doubt merely an indication of strong local currents, together, perhaps, with a slight elevation bringing a neighbouring area of Reading Clay beds under the denuding action of the river which had originally deposited them. From the way in which this pebble-bed shades in some directions into the sands it would seem as though a certain thickness of the latter should be referred to the Oldhaven rather than to the Reading Beds, and, moreover, seeing that the pebbly beds insensibly disappear in certain directions, their absence in some places does not necessarily show that the Oldhaven Beds are there absent. Where the London Clay rests directly on the sands the Oldhaven Beds are very likely represented by the upper portions of these sands, the absence of pebble-beds merely indicating quieter water and absence of strong pebble-bearing currents at these spots when the beds were being deposited.

IV.—On a Section of the Thames Alluvium in Bermondsey.

By A. Santer Kennard and S. Hazzledine Warren, F.G.S.

During the early part of 1899 extensive excavations were made on the south side of Tooley Street, Bermondsey: just east of Shand Street, and on the site of Nos. 156–164, Tooley Street. The spot is about 250 yards from the present bank of the Thames. The whole area was excavated to a depth of about 10½ feet from the level of the pavement; below this, trenches and holes for the foundations were dug to a further depth of 6 to 8 feet. The section on the south side of the excavation is here given.

E. W.



Section of the Alluvium of the River Thames in Tooley Street, Bermondsey.

a, Brownish sandy loam (Marsh Clay) with land shells; *b*, dark-coloured carbonaceous silt with fresh-water shells, Roman pottery, etc., and both ancient and modern piles driven into it under the old stream course; *c*, stratified made earth; *d*, river mud forming the bed of an old watercourse; *e*, brick rubbish; *f*, foundations and cellarage of the old houses.

Scale, horizontal and vertical, 18 feet to 1 inch.

The lowest bed seen, *a*, was a brownish sandy loam with a few pieces of burnt flint, very similar to those commonly seen in

brickearths containing Neolithic flint implements, but nothing resembling a flint implement was found. It yielded a fair number of mollusca at one spot near the eastern end of the section, a small fragment of hand-made pottery, perhaps of Bronze age, a single tooth of a vole, and a few indeterminable fragments of bone. On the eastern side the top of this bed was about 11 feet from the street level, and it occurred almost immediately below the made earth *c*, but towards the west its upper part had been eroded away, and it was only touched at a few places at a depth of 16 to 18 feet.

Immediately succeeding this was a dark-coloured carbonaceous silt, *b*, containing abundant vegetable remains and mollusca. In places there were lenticular masses largely made up of shells. There were very few stones or bones, and no oysters were seen. Several fragments of Roman tile were found. Beetle remains also occurred, as well as numerous ostracods.

The succeeding bed, *c*, was made earth of the well-known London type, containing bones, shells of oyster, mussel, whelk, and *Helix aspersa* ; fragments of pottery and objects of metal, perhaps belonging to the Stuart period, but certainly not older than Tudor.

The western end of the excavation was perhaps the most interesting. Here was the filled-up course of an old stream that ran across the area from south to north. The banks could not clearly be made out, but two rows of well-preserved modern piles 9 to 10 feet apart, with cross-beams and planks nailed on to them, probably marked its artificial banks at some not very distant period. The section of the filled-up bed was :—

3. Modern brick rubbish.
2. Partly stratified river mud, *d*, containing bricks, pieces of roofing slate, lumps of chalk, oyster and mussel shells, bones, and a few non-marine mollusca.
1. Carbonaceous silt, *b*, identical with that present elsewhere in the section.

The junction of the river mud with the bed below was much disturbed, probably by the grounding of boats. In the carbonaceous silt were a large number of ancient piles made of more or less crooked, small stems, or boughs of trees. They were in an advanced stage of decay ; the wood being quite spongy and soft, in this respect contrasting markedly with the modern piles described above.

We would here take the opportunity of thanking Mr. Clement Reid, F.R.S., for kindly identifying the plant remains, Mr. C. O. Waterhouse for naming the insects, and Mr. B. B. Woodward for assistance with the mollusca.

List of Fossils from the Marsh Clay (Bed *a*).

VERTEBRATA.

Microtus glareolus (Shreb.), (Bank Vole).

MOLLUSCA.

Agriolimax agrestis (Linn.).
Vitrea cellaria (Müll.).
,, *crystallina* (Müll.).
Arion ater (Linn.).
,, *hortensis*, Fér.
Pyramidula rotundata (Müll.).
Hygromia hispida (Linn.).
Helicigona arbustorum (Linn.).
Helix aspersa, Linn.
,, *nemoralis*, Linn.
Cochlicopa lubrica (Müll.).
Pupa muscorum (Linn.).

Cæcilioides acicula (Müll.).
Succinea elegans, Risso.
Neritina fluviatilis (Linn.).
Bithynia tentaculata (Linn.).
Limnæa pereger (Müll.).
,, *palustris* (Müll.).
Planorbis Stroemii, West.
,, *contortus* (Linn.).
,, *vortex* (Linn.).
,, *carinatus*, Müll.
Pisidium amnicum (Müll.).

List of Fossils from the Carbonaceous Silt (Bed *b*).

VERTEBRATA.

Homo sapiens.
Sheep or Goat.
Bos longifrons (Ox).
Anguilla anguilla (Eel).
Leuciscus rutilus (Roach).
Rana temporaria (Frog).

MOLLUSCA.

Agriolimax agrestis (Linn.).
Vitrea cellaria (Müll.).
,, *crystallina* (Müll.).
,, *nitida* (Müll.).
Arion ater (Linn.).
Pyramidula rupestris (Drap.).
,, *rotundata* (Müll.).
Hygromia hispida (Linn.).
Helicigona arbustorum (Linn.).
Helix aspersa, Linn.
,, *nemoralis*, Linn.
Carychium minimum, Müll.
Neritina fluviatilis (Linn.).
Bithynia tentaculata (Linn.).
,, *Leachii* (Shepp.).
Valvata piscinalis (Müll.).
,, *cristata*, Müll.
Succinea elegans, Risso.
Physa fontinalis (Linn.).
Limnæa pereger (Müll.).
,, *palustris* (Müll.).
,, *truncatula* (Müll.).
Planorbis corneus (Linn.).
,, *marginatus*, Drap.
,, *carinatus*, Müll.
,, *spirorbis*, Müll.
,, *vortex* (Linn.).
,, *contortus* (Linn.).
,, *albus*, Müll.
,, *Stroemii*, West.
,, *fontanus* (Light.).
Sphærium corneum (Linn.).
,, *lacustre* (Müll.).
Pisidium amnicum (Müll.).
,, *subtruncatum*, Malm.
,, *nitidum*, Jenyns.
,, *obtusale*, Ptr.
,, *milium*, Held.
Littorina littorea, Linn.
Cardium edule, Linn.
Macoma Balthica, Linn.
Mytilus edulis, Linn.

INSECTA.

Pupæ of Diptera.
Pterostichus (*madidus* ?).
Hister cadaverinus.
Geotrupes spiniger.

PLANTÆ.

Ranunculus acris, L.
,, *repens*, L.
,, *sardous*, Crantz
(Buttercups).
Silene Cucubalus, Wibel (Bladder Campion).
Stellaria graminea, L. (Lesser Stitchwort).
Linum usitatissimum (?), L. (Flax).
Vitis vinifera, L. (Grape).
Prunus spinosa, L. (Sloe).
,, *domestica*, L. (Damson).
Rubus fruticosus, L. (Blackberry).
Potentilla Tormentilla, Neck. (Tormentil).
Pyrus Malus, L. (Apple).
Apium nodiflorum, Reichb.
Fœniculum officinale, Adanson (Fennel).
Heracleum sphondylium, L. (Hogweed).
Caucalis nodosa, Scop.
Sambucus nigra, L. (Elder).
Chrysanthemum segetum, L. (Corn Marigold).
Cnicus lanceolatus, Hoffm. (Thistle).
Cnicus palustris, Hoffm. (Thistle).
Centaurea scabiosa (?), L. (Hard-heads).
Sonchus oleraceus, L. (Sow-thistle).
Solanum, sp. (Nightshade).
Prunella vulgaris, L. (Self-heal).
Galeopsis Tetrahit, L. (Hemp-nettle).
Atriplex patula, L. (Orache).
Polygonum aviculare, L. (Knot-grass).
,, *Hydropiper*, L. (Water-pepper).
,, *amphibium*, L.
Rumex conglomeratus, Murr.
,, *obtusifolius*, L.
(Docks).
Urtica dioica, L. (Stinging-nettle).
Ficus carica, L. (Fig).
Alnus ? (Alder).
Quercus (Oak).
Alisma Plantago, L. (Water Plantain).
Potamogeton natans, L. (Pondweed).
Zannichellia palustris, L. (Horned Pondweed).

List of Fossils from the River Mud (Bed *d*).

VERTEBRATA.

Sheep or Goat.
Equus caballus, Linn. (Horse).
Bos longifrons, Owen (Ox).
Sus scrofa, Linn. (Pig).

MOLLUSCA.

Bithynia tentaculata (Linn.).
Valvata piscinalis (Müll.).
Limnæa peregra (Müll.).
,, *truncatula* (Müll.).
,, *stagnalis* (Linn.).
Planorbis Stroemii, West.
,, *contortus* (Linn.).
Planorbis vortex (Linn.).
Sphærium corneum (Linn.).
Ostrea edulis, Linn.
Mytilus edulis, Linn.
Cardium edule, Linn.

Notes on the Fossils.

Bed *a* (pre-Roman). The slug remains were very abundant, especially the granules representing the internal shell of the Arionidæ. The examples of *Helix nemoralis* were large, several measuring 24 mm. in diameter. The Bank Vole was represented by a single typical tooth. The land mollusca were greatly in excess of the fresh-water forms, not only in the species, but still more so numerically. The whole assemblage is that of the fauna of a damp land surface, subject to periodical flooding, the aquatic forms being then washed on to it.

Bed *b* (Roman). In this layer the land shells were comparatively scarce, except in one or two places. The most noteworthy form is undoubtedly *Pyramidula rupestris*, which has hitherto been undetected in a fossil state. It is only represented by one example, but its distribution in these Islands is such that its occurrence in the Pleistocene is to be expected.

Another interesting form is *Sphærium lacustre*, which is an extremely rare form in a fossil state, being only known in these Islands from the Pleistocene of Barnwell and the Holocene (Roman) of London Wall. The facies of the mollusca is that of a typical Thames Holocene bed. There is no trace of any tidal influence, the marine shells without doubt owing their presence to the hand of man.

Note on the Plantæ from Bed *b*. By Mr. Clement Reid, F.R.S.

The list suggests a moist ditch into which a certain amount of house-refuse had been thrown. Most of the species are common plants of wet meadows, but amongst them are remains of several cultivated plants. The vine, damson, apple, and fig occur, and the flax and fennel also were probably cultivated. The corn marigold and hemp-nettle suggest weeds of cultivation, though in this small collection they are not associated with remains of cereals.

There is a close resemblance between this list and that from Roman Silchester, where also seeds of the vine and fig occur. A larger collection from Tooley Street will be of great interest, for the plants should throw much light on the condition of Roman London. Two of the species have not been before obtained from deposits of so ancient a date; they are the bladder campion and the fennel.

Conclusions.

The sandy loam *a* is, in our opinion, the equivalent of the marsh clay present in so many of the sections of the Holocene alluvium of the Thames, and without doubt is of the same origin—a land surface liable to flooding, each flood adding to the thickness of the deposit. The old stream was a tributary of the Thames, and it probably flowed in the same course when bed *a* was deposited. The age of this bed is certainly pre-Roman. The gradual sinking of the lower Thames Valley, which has been in operation since the close of the Pleistocene period, at length enabled the influence of the main stream to be felt, and the carbonaceous silt was deposited. From the presence of Roman pottery in this latter bed it is evident that this did not take place in pre-Roman times, and the deposition of the bed was no doubt carried on for several centuries. Lastly, we have the modern reclamation, the piling of the stream, and finally the filling up of the stream course and the erection of buildings.

V.—On the Base of the Keuper in South Devon.[1]

By Alex Somervail.

WHILE appreciating and agreeing with the valuable work done by Dr. Irving and Professor Hull, dealing with the New Red rocks of South Devon, as set forth in their papers on this subject in the Quart. Journ. Geol. Soc.,[2] there is only one point in which I differ from these authors; it is in relation to the rocks forming the base of the Keuper in this area.

In the last of these papers both authors agree to regard certain breccias occurring at the mouth of the river Otter, and again at the mouth of the river Sid on its eastern side, as the basement beds of the Keuper.

The basement breccias of the river Sid section, as explained by them, are the Otterton breccias again brought up, and repeated by the fault which occurs at the Chit rock, where the sandstones on the east side of the fault are brought up against the Keuper marls on its west side.

The breccias near the mouth of the Otter have been described by Dr. Irving as calcareous or dolomitic breccias, or conglomerates, which I think quite a correct description of these beds. This description, however, *certainly does not* apply to the alleged breccias on the left bank of the Sid, to which I shall presently refer.

The Otterton breccias or conglomerates have been traced inland by Dr. Irving to various localities, all of which I have visited and have found correctly described. The breccias in the inland localities are, however, all along the strike of the Otterton Beds, and not in any case, along the strike of the alleged breccias said to occur in the Sidmouth section.

[1] Read before the British Association, Southport, Section C (Geology), Sept. 1903.
[2] See Quart. Journ. Geol. Soc., vols. xliv, xlviii, and xlix.

The principal object of my short paper is to show that the Otterton breccias are *not again* brought up on the east side of the Sid, or even on its west side at the fault at the Chit rock ; but that they occupy a much lower horizon, and are separated from the beds on the east side of the Sid by a great thickness of sandstones seen between Otterton Point, Ladrum Bay, and the base of High Peak Hill. Still higher beds of these sandstones are even continued further to the west of the latter locality, until they are overlain by the Keuper marls, just before reaching the fault.

My object will be best obtained by a brief description of the coast section between the Budleigh Salterton Pebble-bed and the cliff on the east side of the river Sid.

Immediately overlying the pebble-bed is a considerable thickness of soft red sandstones terminating on the west side of Budleigh Salterton.

Near the Lifeboat Station these sandstones are overlain by another series of sandstones containing breccias, and concretionary-like masses of limestone which are continued to the east side of the river Otter, where the breccias occur which Dr. Irving regards as his Keuper basement series.

From Otterton Point eastwards these breccias are overlain by a series of red sandstones, which can be studied as a slowly ascending series to Ladrum Bay, the base of High Peak Hill, and further along the coast to within a little distance of the fault at the Chit rock.

Between the base of High Peak Hill and some little distance west of the fault the red sandstones are strongly marked by current bedding. The higher portions of these same sandstones are also characterized by a nobbly or concretionary-like structure; but the term breccia, if applied to them, would, I think, be a misnomer. Above these concretionary-like beds are other sandstones of only a few feet in thickness, of a greyish-white colour, which at once pass upwards into the true Keuper marls.

It is highly important to note that it is the effect of the fault at the Chit rock to bring up here, *not the Otterton breccias*, but the higher portion of these current-bedded red sandstones; so that the fault is one of no great magnitude. The entire displacement, I think, is not more than 50 feet, if as much; while the thickness of the sandstones intervening between the Otterton breccias and the line of fault, I would roughly estimate at 150 feet or more.

At the section under dispute on the east side of the Sid, beds still higher in the series occur. These beds consist of the uppermost portion of the current-bedded and concretionary-like sandstones, surmounted by the pale-grey sandstones of only a few feet in thickness which are immediately overlain by the Keuper marls.

The whole thickness of the sandstones with the alleged included breccia and underlying sandstone below the marls in the section figured by Professor Hull[1] would not amount to more than 20 feet

[1] Quart. Journ. Geol. Soc., vol. xlviii, p. 66.

in all; while the Otterton breccias must be separated from the lowest bed of the section here exposed by fully 150 feet.

That the Otterton breccias should form a basement for the Keuper in South Devon, I have no great objections to offer. These breccias, however, as the authors are well aware, are only a small portion of still lower beds of the same nature seen on the west side of that river, and extending along the Promenade until they are underlain by the red sandstones which in their turn overlie the Budleigh Salterton Pebble-bed.

These beds are of considerable thickness, 100 feet or more, and possess many distinguishing features. They are essentially different from any other beds in the Trias. Their dolomitic breccias or conglomerates, and the accompanying masses of concretionary limestone, would almost mark them off as a good representative of the missing Muschelkalk, if this formation has an equivalent in England.

It is the immediately overlying mottled or current-bedded sandstones seen between Otterton Point and the east side of the Sid, that I would regard as the base of the Keuper, in which have been found the remains of the *Hyperodapedon*. This is a point, however, that I would not by any means urge if it be considered that the missing Muschelkalk has no true equivalent or representative in our own country.

The chief object of my paper will have been attained if it is deemed that I have shown sufficient evidence for the conclusions that the Sidmouth section has been misread by Professor Hull and Dr. Irving, and that the Otterton breccias are on a far lower horizon than the alleged breccias (?) in the Sidmouth section.

NOTICES OF MEMOIRS, ETC.

British Association for the Advancement of Science. Seventy-third Annual Meeting, held at Southport, September 9–16, 1903.

List of Papers read in Section C, Geology.

Professor W. W. Watts, M.A., M.Sc., F.G.S., President.

The President's Address.—Geology in Education and Practical Life.

J. Lomas.—On the Geology of the Country around Southport.

Harold Brodrick.—On the Geology of Martin Mere.

A. Smith Woodward, LL.D., F.R.S.—Report of the Committee on the Registration of Type-Specimens of Fossils.

Professor H. A. Miers, F.R.S.—Report of the Committee on the Structure of Crystals.

André Delebecque.—On the Lakes of the Upper Engadine.

H. B. Muff and W. B. Wright.—On a Pre-Glacial or Early Glacial Raised Beach in County Cork.

G. W. Lamplugh.—On Land Shells in the Infra-Glacial Chalk Wash at Sewerby, Yorkshire.

Report of the Committee on the Estuarine Deposits at Kirmington, Lincolnshire.

Report of the Committee on Erratic Blocks.

Report of the Committee to Explore Irish Caves.

Report of the Committee on Underground Waters of North-West Yorkshire.

Report of the Committee on Geological Photographs.

Dr. Wheelton Hind.—On the Practical Value of certain Species of Molluscs in the Coal-measures.

Report of the Committee on Life Zones in the Carboniferous Rocks.

W. S. Boulton.—On the Igneous Rocks of Weston-super-Mare.

J. J. H. Teall, F.R.S.—On Dedolomitization.

A. C. Seward, F.R.S.—Notes on the Fossil Flora of South Africa.

A. Smith Woodward, LL.D., F.R.S.—On a Carboniferous Acanthodian Fish—*Gyracanthides*.

A. Smith Woodward, LL.D., F.R.S.—On the supposed evidence of an Anomodont Reptile from Brazil.

J. Lomas.—On Polyzoa as a Rock-cementing Organism.

T. H. Cope and J. Lomas.—On the Igneous Rocks of the Berwyns.

W. G. Fearnsides.—On the Lower Ordovician Rocks in the Neighbourhood of Snowdon and Llanberis.

E. A. Newell Arber.—On the Fossil Flora of the Ardwick Series of Manchester.

J. Lomas.—Report of the Committee on the Fauna and Flora of the Trias.

A. Somervail.—On the Base of the Keuper in South Devon. (p. 460.)

G. W. Lamplugh.—On the Disturbance of Junction Beds from Differential Shrinkage during Consolidation.

J. G. Goodchild.—On some Contorted Strata occurring on the Coast of Northumberland.

J. G. Goodchild.—Some facts bearing on the Origin of Eruptive Rocks.

J. G. Goodchild.—On a possible Cause of the Lethal Effect of the Dust ejected during the Recent Volcanic Eruptions in the West Indies.

J. G. Goodchild.—Notes on the Metalliferous Deposits of the South of Scotland.

J. Jowett.—Glacier Lakes and Overflow Valleys in the Neighbourhood of Rimington.

William MacKie.—On the Origin of Continents and Ocean Basins.

W. Whitaker, F.R.S.—Report of the Committee on Changes along the Coastline of the British Isles.

H. W. Monckton.—Notes on the Sarsen Stones of Stonehenge and on those found in the Bagshot District.

Llewellyn Treacher.—On the occurrence of Stone Implements in the Thames Valley, between Reading and Maidenhead.

J. Lomas.—On the Origin of certain Quartz Dykes at Foxdale, Isle of Man.

H. J. Seymour.—Supplementary List of Minerals known to occur in Ireland.

F. P. Mennell.—On the Average Composition of the Igneous Rocks.

Papers bearing on Geology read in other Sections :—

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

J. Milne, F.R.S.—Report of the Seismological Committee.

D. Burns.—Phenomena accompanying the Volcanic Eruptions in the West Indies.

SECTION E.—GEOGRAPHY.

Captain E. W. CREAK, C.B., R.N., F.R.S., President.

President's Address (refers to Terrestrial Magnetism and Geology).

Dr. Tempest Anderson, M.D., B.Sc.—The Recent West Indian Eruptions.

C. E. Moss.—Peat Moors of the Southern Pennines: their Age and Origin.

SECTION G.—ENGINEERING.

CHARLES HAWKSLEY, M. Inst. C. E., President.

President's Address (refers to Water Supply).

J. Campbell Brown.—On the Nature and Quality of some Potable Waters in South-West Lancashire.

J. Parry.—Water Supply and South-West Lancashire.

R. Pearson.—History of the Discovery of Natural Gas in Sussex.

SECTION H.—ANTHROPOLOGY.

J. G. Garson, M.D., and W. J. Lewis Abbott.—Some Recent Excavations at Hastings, and the Human Remains found.

Mrs. Stopes.—Palæolithic Implements from the Shelly Gravel Pit at Swanscombe, Kent.

Mrs. Stopes.—Saw-edges in Flints from Swanscombe, Kent.

Nelson Annandale, B.A.—The Survival of Primitive Implements in the Faroes and Iceland.

SECTION K.—BOTANY.

A. C. SEWARD, F.R.S., F.G.S., President.

President's Address.—Floras of the Past: their Composition and Distribution.

Dr. D. H. Scott, F.R.S., and Professor F. W. Oliver.—The Seed of *Lyginodendron.*

W. Wilson.—The Plants on the Serpentine Rocks in the North-East of Scotland considered with reference to the Soil Ingredients.

REVIEWS.

I.—Catalogue of the Madreporarian Corals in the British Museum (Natural History). Vol. IV: The Family Poritidæ. 1. The genus *Goniopora.* By HENRY M. BERNARD, M.A. 4to; pp. viii and 206, with 14 plates. London: printed by order of the Trustees, 1903. Dulau & Co., Soho Square.

THIS is the fourth volume on Corals issued by the Trustees of the British Museum (Natural History). Vol. i, by the late George Brook, on the genus *Madrepora*, appeared in 1893 (pp. xii and 212, with 35 quarto collotype plates of the genus *Madrepora*); there were at that time in the collection 1104 specimens, described

by Mr. Brook under 180 specific names, the total number of species of the genus amounting to 221. Vol. ii, embracing the genera *Turbinaria* and *Astræopora*, was, through the lamented death of that accomplished zoologist Mr. George Brook, undertaken by another excellent biologist, Mr. Henry M. Bernard, M.A., F.L.S., F.Z.S., and appeared in 1896 (pp. iv and 106, with 33 plates). Vol. iii, containing the corals of the genera *Montipora* and *Anacropora*, prepared by the same author, was issued in 1897 (pp. viii and 192, with 34 plates 4to). In 1897 the late Sir William Flower, then Director, writing in the Preface, said: "The three volumes now finished form together a very complete monograph of the Madreporidæ, which is one of the chief reef-building families of Stony Corals. . . . In 1878, when Brüggemann prepared his manuscript catalogue, there were only 41 specimens of Montipores, divisible into 16 species. There are now more than 400 specimens, classed under 116 species, about 80 of which are new."

In the preface to vol. ii Mr. Bernard refers (pp. 19–21) to the difficulties which beset the systematic naturalist in attempting to establish a standard upon which to divide Corals into groups—say according to their methods of growth. These methods of growth, which at first seem so convenient, are found to pass into one another, so that it is most perplexing to decide whether a specimen exhibits one or the other type of growth.

Again, the number of transitional forms observable in a long series of specimens, which, from their calices, are clearly related, renders it difficult to decide as to which group they properly belong. Still more serious is the fact that in Torres Straits we find Turbinarians widely differing in the character of their calices, yet revealing exactly the same methods of growth, which shows that in that case at least the form of the corallum is due to the environment. Often, too, special local forms of growth are confined entirely to limited areas.

A year later, writing at p. 17 in vol. iii, Mr. Bernard says: "While claiming that the chief divisions of the genus are natural divisions, I can only repeat what was said in the preface to vol. ii as to the real value of the specific divisions. The types represent merely the more marked variations presented by the specimens in the collection, and are therefore for the most part purely artificial groupings. Only in those cases in which the individual specimens are known to have been collected from the same locality, and might almost be fragments of one and the same colony, does the name imply the close blood-relationship which the word species should be taken to connote. In all other cases the types are, strictly speaking, only morphological groups united because of certain peculiarities of form or structure which they have in common. Their ultimate systematic value is thus problematical. How much this is the case, indeed, may be gathered from the fact that the differences presented by specimens which are undoubtedly specifically identical may be far more striking than those that separate many of the types."

"The influence on the mind of the puzzled worker by such a group of many individuals, showing great variations, yet undoubtedly specifically identical, leads him, as a rule, temporarily to a wholesale lumping of other specimens, until his courage fails him, when the more striking individual variations are once more separately described as new types."

The above extracts will serve to convey the feelings of the author in regard to the use and limitation of the term 'species.' Indeed, so far back as 1896 he wrote: "It seems to me certain that we are rapidly nearing the time when our ever-increasing collections, revealing as they do the infinite grades of variation presented by living organisms—especially by stock or colony-forming animals, such as corals, in which the varying factors are doubled,—will compel us to break loose from the restraint of the Linnean 'species.'"

We come now to the latest issue of Mr. Bernard's work on corals (vol. iv, August, 1903), issued under the favourable auspices of Professor E. Ray Lankester's administration as Director and Keeper of Zoology. By the Director's advice, the author has made a special study of the rich collection of fossil corals contained in the Geological Department, which has revealed the fact that an important Tertiary coral, *Litharæa*, is generically identical with *Goniopora*, and this genus can now be traced back to early Cretaceous times, and had its period of maximum development in the early Tertiary beds of South Europe. The fossils, moreover, throw much light upon the morphology of the genus.

"The variability of the corals" (writes Professor Lankester) "has, in previous volumes, been a good deal obscured by the establishment of a number of so-called species; the author has thought it right to cease establishing genetic groups without the necessary data for so doing. He regards his task as that of presenting the facts and what may legitimately be deduced from them in the way that will be most useful to future workers and to the officials of other museums. Experience alone can show whether the method he has adopted in order to attain this end, however faultless its logic may be, can be employed with advantage in dealing with any other group besides the corals, or even whether it is the best way of presenting the corals, having regard solely to the facts. The attempt is, however, a sign of the times, for it is clear that, whether the older school of systematists like it or not, the question of method is an increasingly serious one, and Mr. Bernard's attempt should stimulate inquiry outside the beaten paths." (Introduction, p. i.)

The first thing that will strike the reader is the change in the formula, the author having completely abandoned the old methods of naming in favour of geographical symbols.

"It must, of course" (writes Mr. Bernard, p. 190), "be at once admitted that names like those usually employed to indicate species might have been used instead of geographical symbols. But the objections to names seem to be many and serious.

"A 'specific name,' by long usage and almost universal agreement, implies a true genetic group, and my experience has been that no explanation as to the meaning assigned to the use of the name can change this. When we are not dealing with species, but with forms, from the ultimate grouping of which species may perhaps be discovered, the work is confusing if the method of designation for the forms is that used for species. Some special method is needed for this preliminary analytical stage of work. Only when the natural groups have been discovered should names be used.

"The use of some special symbol for this preliminary study becomes obvious if we picture to ourselves what must happen as soon as true genetic groups or species can be compounded from series of known forms. One of the names will be retained as the name of the species, others as the names of varieties, while the rest will have to be discarded as mere synonyms. Working symbols have this advantage over ordinary specific names, that they can be legitimately discarded if we so desire. But it seems to me that, while we would certainly desire to discard a wearisome and perfectly unintelligible list of synonymous *names*, there would be no desire to discard synonymies composed of geographical symbols, for they would give at a glance the geographical distributions of the species and of its several varieties.

"The attempt here made to record forms is being made in other groups besides corals, but so far only in such groups as have already been divided into species. The process involves the addition to the accepted specific name of one or more qualifying names, one of which invariably indicates the locality. In this way the old binominal designation of Linnæus is forming the basis for a multinominal system of recording the various forms which we now find embraced by the species. This system cannot be adopted in the corals, for the simple reasons that only a very small proportion of the corals have yet received any names at all, and only a few of those which have been named can now be identified. The process is, therefore, not one of designating the forms which make up established species, but of recording forms which may some day be grouped into species. We who are working with corals, then, are in a position favourable to the adoption of a new and more straightforward method of dealing with the species problem. In reality we are still in the throes of sorting out genera, and all the most solid work of the past is chiefly valuable in this respect. Even this stage is far from complete. The task, therefore, is complicated, and the new method should be technically simple, practical, and efficient.

"The question thus arises, whether names or symbols best fulfil these conditions. Names, when there are only a few of them, may be easier to remember, but long lists are a dead weight upon the work. While there may ultimately prove to be but few *groups* or *species* requiring names, the number of *forms* to be designated is bound to be very large. For example, the analytical tables which now give at a glance the geographical distribution of the different

structural divisions would have been far less useful if meaningless names had been given to the forms. It seems to me that we have no other alternative than that between 'trivial' names and symbols. It is not possible to invent a long list of short names, each one of which shall convey useful information, except on some fixed plan, and that, sooner or later, means the construction of symbols or of symbolic names." (p. 191.)

Notwithstanding this bold and determined attempt to reform zoological nomenclature, and to rid us of the long lists of synonyms which fill so many pages of every systematic work, the author has to admit that he has been warned again and again that there are rigid formalists who firmly believe they would be doing zoology a service by *naming*, that is, "*making species*" of, all the forms here recorded by geographical symbols. Mr. Bernard, from recent experience, finds he is compelled to respect this warning and to give a list of Latin equivalents for his geographical symbols which may stand instead of *specific names*, which the *rigid formalist* may catalogue and accept as such. One hundred and forty-four of these provisional names are listed, each preceded by the author's symbol, which he is warned will not be accepted in lieu of a name, so they read thus:—

Goniopora: (symbol) *G. New Guinea* 1 (which stands for, or is) = *Goniopora Nova-guineensis prima* [and in those cases in which the forms have been assumed by previous writers to represent separate and distinct *species*, the name of such species is given in brackets; thus to the above name we must add (*G. pedunculata*, Quoy & Gaimard)]; *G. New Guinea* 2 = *G. Nova-guineensis secunda*; *G. New Ireland* 1 = *G. Nova-hibernica prima*; *G. Solomon Islands* 1 = *G. Salomonis prima*; and so on.

Two objections present themselves to Mr. Bernard's admirable proposals—yea, three might be urged—(1) The symbol alone is insufficient. (2) The name in full in addition or in place of the symbol is *too long*.[1] (3) Is it not unfair to annex all the geographical names for one group? Furthermore, it involves the introduction of the *trinomial system* into zoology, which is certainly not a thing to be greatly desired. The symbols alone, we fear, will not meet with cordial acceptation in any case.

The main difficulty which will be felt by systematic zoologists in adopting Mr. Bernard's method of nomenclature in corals is that it is unlike that in use for similar natural divisions, so that this class of organisms must stand aloof from, and cannot conveniently be brought into line with pre-existing arrangements of other orders and families.

Whatever attitude we may adopt with regard to Mr. Bernard's system of nomenclature we must all be most grateful to him for one thing, namely, that he has taken in hand the long neglected

[1] Especially when we have so often to use some other name as well to qualify it, as pointed out above (viz. *G. pedunculata*, Q. & G.). There are 51 such additional recognised names which must be used and cannot be set aside.

fossil Zoantharia, and is tracing out their existing relationships with the same careful and philosophical attention which he has bestowed upon the living corals.

In the present volume the author writes (p. 28): "The Eupsammiidæ and *Goniopora* appear to have arisen in Mesozoic times, the earliest known Goniopore being from the Lower Cretaceous formation of the Crimea, since which time the perforate corals have flourished, belonging for the most part to the Tertiary period." (Earlier corals, claimed to belong to the Poritidæ, including *Calostylis*, of Lindström from the Silurian, have so far not borne the test of examination.) Mr. Bernard then proceeds to deduce the origin of *Goniopora* and *Porites* (forming the Poritidæ) and the Madreporidæ from the Eupsammiidæ.

These primitive relationships are illustrated in the following scheme. A primitive porous coral, that is, a parent form in which the epithecal cup, or the prototheca, is flattened out, and the secondary theca is built of septa joined by synapticulæ:—

Simple and simply branching forms.	Luxuriantly branching forms, owing to early budding and consequent dwarfing of the polyps, but with rapid growth in height of theca.	Astræiform colonies, due to early budding while the skeleton is incomplete, basal and disk-shaped.
The Eupsammiidæ.	**The Madreporidæ.**	**The Poritidæ.**
[? Including TURBINARIA.]	[? Excluding TURBINARIA.]	GONIOPORA.
		By suppression of tertiary septa.
		PORITES.

The author inserts under "Geographical arrangement of forms" all the fossil genera and species where they appropriately belong.

Thus at p. 92. Group V, **India and Persia**, *containing descriptions or records of fossil Gonioporæ from Sind* (1–7), *Indus River* (1), *Persia* (1–4).

62. *Goniopora*, **Sind** (7) 1; and then in what we should consider the synonymy we find:—

Litharæa epithecata, Duncan: Sind Fossil Corals, Mem. Geol. Surv. India, 1880, p. 23, pl. ii, figs. 1–9; Geol. Dept. R. 13, presented Geol. Surv. India.

A full description follows, and of 11 other species (pp. 92–99). Under Red Sea and Egypt, 3 fossil forms are described (pp. 99–107). Under Italy, fossil *Gonioporæ* are described from Vicenza (1–13), Verona (1–2), Alexandria (1–3), Turin (1–3), Genoa (1–5), (pp. 107–122). Under Austria-Hungary we find Miocene corals from Vienna, Cretaceous from Bohemia, etc. Under France we have many forms from the Miocene of Dax, Gironde, Paris Basin, Coutances, etc. (pp. 128–146). Under England we find fossil

Gonioporæ from Bracklesham Bay and Brockenhurst (pp. 147–153). Russia furnishes a Lower Cretaceous form from the Crimea (pp. 153–154). There is also a form from the Eocene of Somaliland described by Gregory. In the analytical tables of results (pp. 162–168) the fossil forms have their appropriate places, as e.g. No. 46, Java Sea 2 and 3, Valley of the Tjilanang, Ronga, Upper Miocene, and 4, near Liotjitjangkang, also U. Miocene. Then Eocene, India; Miocene, Persia; Eocene, Egypt; and so on, down to Upper Cretaceous, Bohemia, and Lower Cretaceous, Crimea.

The last table gives us a summary of the whole of the known forms of *Goniopora*, with their geographical and geological distribution, showing Cretaceous 5, Eocene 35, Oligocene 20, Miocene 19, Pliocene 1, Pleistocene 1, Recent 70, giving a grand total of 151 forms, or *possible* species.

There is an interesting survey of growth-forms and their distribution (pp. 169–186), and the summary of results (pp. 187–189). "The only specimens" (of corals), says Mr. Bernard, "showing unmistakeable genetic affinities are those which have been gathered from the same spot and are obviously daughter-colonies of one and the same parent."

"The largest area over which such a genetic group is as yet known to spread is that of the Maldive Islands. One simple form of Gonioporan colony, with calicles which are those characteristic of its type of growth, has been discovered by Mr. Gardiner occurring at considerable depths round at least four of these islands," the evidence showing that they are all alike developed on a soft muddy bottom. "This determined *the growth-form*, and this is largely responsible for the type of the calices" (p. 188). Mr. Bernard thinks that "The Stony Corals are still too elementary in their organisation to be able to acquire any but transient stability, if such an expression can be admitted; they also respond very quickly to their environment."

"The chief results, then," says Mr. Bernard, "are practically all that could be expected from the relatively small amount of the material. They are almost exclusively morphological, phylogenetic, and biological. The systematic arrangement of the forms in the order of their evolution cannot yet be attempted."

We desire to record our admiration for the plates, especially those of the present volume, in particular plates i to x^b, giving enlarged views of portions of growth-forms from various examples (numbers and localities given in each case). These, which are enlarged five times natural size by photography, far exceed in beauty and accuracy of detail those of the previous volumes.

We heartily commend Mr. Bernard's work to the attentive consideration of all zoologists, and more especially of those who are interested in recent and fossil corals, although, if the author carries his point, all the *species* of corals must, in the near future, remain nameless, like the 'Masque de Fer,' or be represented only by a locality and a number!

II.—Memoirs of the Geological Survey of England and Wales.

1.—The Geology of the South Wales Coalfield. Part IV: The Country around Pontypridd and Maes-Têg, being an account of the region comprised in Sheet 248 of the Map. By Aubrey Strahan, M.A., F.G.S., R. H. Tiddeman, M.A., F.G.S., and Walcot Gibson, B.Sc., F.G.S. 8vo; pp. vi and 134, with plate of sections and 6 text illustrations. (Issued July, 1903; preface dated 28th February, 1903. Price 1*s.* 6*d.*) Illustrating Sheet 248 of the Geological Map of England and Wales (scale 1 inch to 1 mile), colour printed. (The map is sold separately, price 1*s.* 6*d.*)

2.—The Geology of the Cheadle Coalfield. By George Barrow, F.G.S. 8vo; pp. iv and 62, with 2 illustrations in the text and geologically coloured map of the Cheadle Coalfield. Price with map, 2*s.* (Preface dated 12th March, 1903.)

3.—Summary of Progress of the Geological Survey of the United Kingdom and Museum of Practical Geology for 1902, with Introduction by J. J. H. Teall, M.A., F.R.S., Director. 8vo; pp. iv and 240, with 9 illustrations in the text. London, 1903 (received 20th August, 1903). Printed for H.M. Stationery Office; sold by E. Stanford, London, etc. (or of Messrs. Dulau & Co., 37, Soho Square, W.). Price 1*s.*

THE Geological Survey memoirs recently published, whose titles we quote above, are of considerable interest.

1. The first of these is a continuation of "The Geology of the South Wales Coalfield,"[1] comprised in Sheet 248, and is the fourth part of the memoir descriptive of this region, including the important part of the coalfield extending from Pontypridd on the east to Cwmavan on the west, and from Aberaman and Glyn-corwg in the north to Llantrisant and Mynydd Margam in the south, embracing the greater part of the range of the best steam-coal.

Sir H. T. De la Beche, Sir W. E. Logan, and Mr. D. H. Williams made the first survey of this area on the old map; probably most of the work was by De la Beche himself, but the western part was surveyed by Logan before his connection with the Geological Survey. The original maps were exhibited by Logan in 1837 at the British Association in Liverpool, and attracted the attention of De la Beche, with the result that they were handed over to the Geological Survey and incorporated in the official maps, while Logan himself became a member of the staff. Sheet 36 was published in or before the year 1845.

The re-survey was made on the 6 inch scale, under the superintendence of Mr. Strahan, and published in 1899. The eastern part of Sheet 248 was surveyed by Mr. Strahan, the south-western part by Mr. Tiddeman, and the northern part by Mr. Gibson.

[1] See previous review, Geol. Mag., June, 1903, p. 269.

Each geologist contributes an account of the area surveyed by himself, and the whole memoir has been edited by Mr. Strahan.

Two subdivisions of the Coal-measures, namely, the Pennant series and the Lower Coal series, occupy nearly the whole area. In the latter occurs a group of seams which yield the well-known smokeless steam-coal. These seams are illustrated in the present memoir by a folding plate giving six vertical sections; various other sections are also given in the text, while sheets of vertical sections, Nos. 83–85, are published separately. The seams of the Lower Coal series vary greatly in thickness; thus, in the Aberaman Colliery in a section prepared by Mr. E. M. Hann (given in detail on pp. 12–14 of this memoir), in a depth of 283 yds. 1 ft., or 850 feet, no fewer than 28 seams are passed through having an aggregate thickness of 15 yds. 2 ft. 8 ins.; but of this amount only 4 seams are more than a yard in thickness, 5 are over 2 feet thick, 11 exceed one foot in thickness, and 8 are less than a foot; so that it is probable that not more than 9 out of the 15 yards in thickness of coal, if even so much, are won at this colliery. It may be of interest to notice that, though the seams can be recognized for long distances in an east and west direction, yet both these and the measures associated with them change so rapidly southwards that only a general correlation by groups is possible. In this part of the coalfield some massive sandstones, much resembling Pennant, develop in the upper part of the Lower Coal series.

The Pennant series shows a no less remarkable expansion both in a southward and westward direction. At the same time its upper part becomes split up by shales and coal-seams, which have yielded the bulk of the coal near Neath, Swansea, and Llanelly. Thus both the top and the bottom of the Pennant is less distinct than in Monmouthshire, where the subdivision consisted almost exclusively of sandstone.

The Upper or Llantwit Coal-measures occur in two small outliers only in the area comprised in Sheet 248.

In the South Crop, where the high dip usual in the southern margin of the coalfield prevails, the Millstone Grit and what may be the top of the Carboniferous Limestone come into view, but they are partly overspread by Triassic strata, which have been laid down unconformably upon their truncated edges. The Coal-measures themselves are partly thus covered, and it is worthy of note that the Triassic conglomerates consist, not of Coal-measure rocks, but of fragments of Carboniferous Limestone.

The Secondary rocks, which include Keuper, Rhætic, and Lias, are described in a separate chapter. They enter the map under description along its southern margin only.

The faults and disturbances are grouped into (1) the east and west folds and the Moel Gilan Fault, and (2) the north-north-westerly faults. They are discussed in detail in chapter viii.

Chapter ix, after giving a general account of the glacial deposits, deals with their occurrence in each valley. In chapter x the principal economic products of the region are enumerated.

The map (price 1s. 6*d.*), which is very carefully printed in colours, is published in two editions, on one of which (the Solid Edition) glacial deposits and the like are omitted, while on the other (the Superficial Edition) such deposits are indicated by colour, as well as those portions of the solid geology which are not concealed by Drift. The map of the solid geology, being nearly all covered by the Coal-measures, the symbol of which is an olive-green colour, has a sad and mournful effect, and renders it rather difficult to decipher the names of places upon it. We think it might be possible to use a somewhat paler colour with advantage. Manuscript six-inch maps geologically coloured are deposited in the Survey Office, Jermyn Street, where they can be consulted, and copies can be obtained at cost price.

2. "The Geology of the Cheadle Coalfield," by George Barrow, forms a small but excellent memoir, complete in itself, of an outlying portion of the North Staffordshire Coalfield, full particulars being given of the various seams of coal, with records of borings and remarks on the probable extent of the workable Coal-measures. A good diagram-section across the coalfield is given on p. 49, showing the various workable coal-seams. There are 17 seams of coal, two being 6 feet in thickness, three over 3 feet thick, seven of 2 feet and upwards, and the remainder only about one foot in thickness.

Details of the underlying Millstone Grit series and the overlying Bunter and Keuper formations are also furnished, and special reference is made to the water-bearing strata. The Glacial Drift and other superficial deposits are described, and the memoir is accompanied by a small but excellent colour-printed geological map, a plan we hope to see followed in the issue of every separate Survey memoir.

The area described in this small memoir is remarkable for the fact that its main features are of two widely different ages. What may be broadly called the northern portion, is composed of Carboniferous rocks, forming a sloping tableland essentially of pre-Triassic age, though modified of course by later denudation. Upon this older land-surface the Triassic rocks were deposited, but have since been denuded off all except a small portion of the northern area; thus restoring, as it were, the old pre-Triassic surface. In the southern area, however, these rocks have escaped denudation to a considerable extent, and now form a second and newer tableland, overlooking the first and older one. The true form of the older tableland is somewhat obscured locally by the hill of red sandstone at Cheadle, but from the summit of the hill it is at once seen that this isolated eminence is simply a detached portion of the newer Triassic plateau, and really serves to emphasize the fact that these rocks do form a tableland.

The highest ground occurs in the northern area, formed of Carboniferous rocks, attaining an elevation of 1,000 feet about Ipstones, and 800 feet in the neighbourhood of Wetley Rocks. The Triassic rocks do not attain so great an elevation; at the edge

of the plateau overlooking Cheadle the ground maintains a fairly uniform height of 700 feet above sea-level, and the top of the hill at Cheadle is at the same height.

The drainage of the area is effected by the two rivers the Churnet and the Tean and their branches. Of these the Churnet is much the larger, and flows for the most part in a deep valley, often almost a gorge; and so regular on the whole is the plateau on both sides of the river that it is often possible to look across the deep valley without realising its existence. The chief branches of the Churnet are three in number, and flow through the Consall Woods, the valley between Ipstones and Froghall, and the beautiful gorge of Dimmings Dale. The gorge is renowned for its steep, craggy, and densely wooded sides. It is cut in the Triassic rocks; the other two channels are in the Carboniferous. Though less gorge-like than Dimmings Dale they both have steep and craggy sides locally. The country about Cheadle is drained by small streams flowing in shallow hollows, which unite to form the Tean, and eventually flow into the Churnet to the south of this area.

Much of the ground is permanent pasture, and this is specially the case where the soil is formed of the heavy Carboniferous shales and clays. Of the lighter lands, formed of the sandstones and grits of this formation, a considerable portion is under the plough, and the same is true where the soil is formed of the dry Triassic sandstones. Even here, however, may be noted the same tendency to lay ground down in permanent pasture that is seen in many other parts of England.

Several minor industries are carried on in the district. Of these silk-spinning at Cheadle is mainly due to local cheapness of production; a manufacture of which the town of Leek may be taken as the centre. Brick-making is carried on to a considerable extent, the Coal-measure shales and clays being employed for this purpose. The bricks are of excellent quality.

There are large copper-works in the Churnet Valley close to the railway at Froghall and Oakamoor. The industry is still retained, although the original deposit of copper-ore at Ecton Hill which gave rise to it has been long since abandoned. There were also formerly brass-works near Cheadle which had a high reputation, but these have fallen into decay.

Coal-mining is the most important industry of the district, and gives employment to a considerable number of men. There are at present six collieries at work, but only two, the Foxfield and the Delphouse, are connected with a railway, so as to be able to send coal out of the district; the others can only supply local needs.

The coal-workings of this district are of great antiquity. They can be traced back as far at least as the reign of Richard III. The coal-seams outcrop at the surface, and, not being concealed beneath drift or Boulder-clay, were ploughed up in the fields, and so came to be early recognised and used as fuel. In the majority of cases the old workings for coal were started from the outcrop, and therefore required no great engineering skill to develop. They all appear

to have been arrested by the influx of water into the workings, although in one instance they evidently displayed some considerable intelligence in draining a particularly good seam between Belmont Hall and Ipstones by driving a level to carry off the mine water.

3. The Summary of Progress for 1902 conveys an excellent idea of the vitality of the Geological Survey, under its present able Director, Mr. J. J. H. Teall, F.R.S., whose zealous activity in planning the work is only equalled by the energy displayed by his staff in carrying it into execution.

In England and Wales the field-work has mainly covered four areas—Devon and Cornwall, South Wales, the Midlands, and the London district. In Scotland the work has been distributed over six districts, four being in the unsurveyed portion of the Highlands and two in the Carboniferous areas of the Midland Valley. In Ireland the Drift Survey was continued in the neighbourhood of Belfast. A few of the more important features of the work of the year may be referred to here.

Highland Metamorphic Rocks.—Probably the oldest rocks with which the Survey has had to deal in the course of the year occur in the Highland metamorphic region. Previous work in the areas occupied by the Eastern Highland schists in the north of Scotland have demonstrated the existence of extensive tracts of country composed of rocks closely resembling certain portions of Lewisian gneiss, especially those which occur in zones of secondary shearing. Those varieties of gneiss to which reference is made consist of alternations of acid and basic material, with occasional lenticles of ultra-basic rock; but they differ from the unmodified gneisses in possessing a granulitic structure. Two belts composed of rocks of this type have been met with by Mr. Hinxman in Strathconan Forest, Ross-shire, where they are seen to be most intimately interfolded with siliceous granulites of the Moine type. Although the exact meaning of these facts is not apparent, it may safely be predicted that they will be found to have a most important bearing on the origin of the Eastern Highland schists of Sutherland and Ross.

Other facts bearing upon the same subject have been observed by Mr. Clough in central Ross-shire, a granitic rock at some early period having been intruded into sediments which have been converted into hornfels by contact-action. Zones of thrusting and shearing comparable to those which have been described in the Lewisian gneiss traverse both the granitic area and that occupied by the altered sediments, the hornfels having, as a result, been converted into mica-schists, and the granitic rocks into finely foliated augen-gneisses, with a granulitic matrix.

Important observations have been made in the Southern Highlands by Dr. Peach and the officers acting under his direction, both on the mainland and the islands of Argyllshire.

The great quartzite formation of Islay and Jura, which has been split up into several recognizable zones, in some of which flattened worm-casts (*annelide-burrows*) occur, has been followed into Scarba, and evidence obtained that the boulder-beds, so well developed in

the Isles of the Sea, form the natural base of this group of strata. These beds contain fragments, many of which are rounded, of the underlying Degnish and Shuna Limestones.

In the Eastern Highlands the characters and relative ages of the complex igneous intrusions have been studied, but this subject is still *sub judice*.

Torridonian.—The Torridonian rocks, as they are developed in Rum, have been described by Mr. Harker, who shows that they have been affected by the post-Cambrian thrust-movements. In the north-west of the island a prominent crush-breccia, composed of lenticles of Cambrian limestone and crushed sandstone, overlies the thrust-plane.

The detailed mapping of the *Lower Palæozoic rocks* on the north side of the Carboniferous area in South Wales has shown that the anticline in which the oldest rocks come to the surface follows the Towy Valley, and Messrs. Cantrill and Thomas have recognized an inversion which has had the effect of bringing the *Didymograptus bifidus* shales over the Llandeilo Beds.

Old Red Sandstone and Devonian.—Additional evidence of the fact that the lavas of Lorne plateau were poured out on an uneven surface formed of the Highland schists has been obtained in the course of mapping the southern margin of this plateau to the north of Loch Melfort, and definite proof of the Lower Old Red Sandstone age of the Glencoe volcanic rocks has been furnished by the discovery of *Psilophyton* in shales which are associated with the lavas.

In England the Old Red Sandstone rocks on the borders of the South Wales Coalfield have been examined, and evidence of a powerful strike fault, or rather series of faults, traversing the central portion of the northern band has been obtained. "The course of this disturbance," as Mr. Strahan says, "along the middle of the outcrop of the Old Red Sandstone for so many miles, its effect in throwing in patches of Carboniferous Limestone by what must be an enormous displacement, and lastly, the guiding influence which it has exerted upon the rivers, in common with other disturbances, of the east-north-east and west-south-west system, all combine to give it an unusual interest."

In North Cornwall the purple and green slates with *Pteraspis* which occur in Watergate Bay have engaged the attention of Mr. Reid. They are of special interest as indicating, both by their fossil contents and lithological characters, the existence of the Old Red Sandstone facies within the Devonian area.

The work of mapping the coalfields of England on the six-inch scale has been continued in South Wales and in the Midland counties, while in Scotland the work of revising the old six-inch maps has commenced. In South Wales the mapping of the coalfield proceeds steadily towards the west, and much information as to the correlation of the coal-seams and the nature of the disturbances will be found in this Summary of Progress. Three systems of faulting or folding exist. The steep uplift which determines the southern margin of the coal-basin and the Llanelly syncline belong to the

pre-Triassic system, which traverses the Vale of Glamorgan. A long series of north-north-west faults, the course of which across the pre-Triassic folds has been worked out in detail, belongs to the system which is certainly in part of post-Triassic, but probably in part also of pre-Triassic age. Lastly, a series of parallel disturbances of great magnitude, which traverse the northern part of the coalfield, the Old Red Sandstone and the Lower Palæozoic rocks, and which have determined the river drainage, may be assigned to the system of which the Neath disturbance is a well-known example. This third system, which is characterized by folding and overthrusting on a large scale, runs in a general west-south-west direction, and from its remarkable influence on the surface configuration is believed to be of later date than the others.

In the Midland district the work has been confined to the southern and western part of the Derbyshire and Nottinghamshire Coalfield. Mr. Wedd has mapped out the various beds of Millstone Grit which were not separated in the original survey, and one result of his work has been to relegate a considerable tract of country which was formerly regarded as Coal-measures to the Millstone Grit formation. Mr. Gibson has continued his researches on the higher measures of this coalfield, and has obtained additional evidence to prove that beds above the Top Hard, which have been brought to light in the Gelding shafts and in the Thurgarton boring, are palæontologically, lithologically, and stratigraphically comparable with the higher measures occurring in other Midland coalfields. As he points out, there seems no escape from the conclusion that the Pennine elevation, with the consequent breaking up of the syncline, was subsequent to their deposition. He has also obtained evidence of the existence of marine conditions during the deposition of the Coal-measures at several horizons, both low down and high up in the series, and in view of these facts he naturally asks whether a much larger proportion of our Coal-measures has not been formed under marine conditions than is generally supposed. In working out the palæontology of the coal Mr. Gibson has received valuable aid from Dr. Wheelton Hind, whose name frequently recurs in this Summary of Progress.

In Scotland the revision of the Carboniferous areas has been commenced in the eastern part of the Midland Valley. Mr. Wilson has re-examined the oil-shale field to the west of Edinburgh, and calls attention in his report to the fact that the shales in that region, with few exceptions, deteriorate both in the quantity and quality of the oil as they are followed downwards. If this should prove to be a general law, it will obviously have a very important bearing on estimates of the value of any area in which the oil-shale horizons exist, and raise an interesting problem as to the nature of the processes by which the oil-producing compounds have been concentrated near the existing surface.

The examination of the coast between Dunbar and Cockburnspath has enabled Mr. Clough to prepare a detailed section of the Carboniferous Limestone series, and to show that the beds which dip under the sea along a portion of the coast are probably very near

the base of the Edge coals of Midlothian. These coals may therefore exist beneath the sea under conditions which will enable them to be worked at some future time.

But the most striking addition to our knowledge of the Carboniferous rocks of Scotland is that furnished by Mr. Kidston's examination of a large suite of plants from the Canonbie Coalfield, in the collection of which he was assisted by Mr. Macconochie. This proves that Upper, Middle, and Lower Coal-measures are here present. According to Mr. Kidston the highest measures are on the horizon of the Radstock Beds, an horizon which is higher than any reached in the midland or northern coalfield so far as is at present known.

The Permian and Trias, the Jurassic and Tertiary deposits have also received attention during the past year, but we cannot now dwell with greater detail on the Summary before us, which deserves to be more fully studied by all who take an interest in the progress of geology in the British Isles.

CORRESPONDENCE.

COMMENTS ON A COMMENTATOR.

Sir,—As my name has been made prominent in more than one part of the last number of the Geological Magazine, permit me to say that I see no reason to modify what I said (1895, p. 75) about the Budleigh Salterton pebbles, and cannot admit that Mr. Shrubsole is right in asserting the oblate spheroidal form to have been acquired by rolling on the beach. To this point I paid particular attention, with what result may be seen in the following extract from my diary. After some notes on size, form, and colour, it goes on—"I think these peculiar, almost semicircular ellipsoids are rather commoner on the beach than in the cliffs, perhaps due to their being a little more worn and selected. Nevertheless, they are generally the dominant form in the sections, but are less conspicuous from being half buried." This flattened form could not be acquired by wave-action alone, but must be initiated by a certain original 'slabbiness' in the rock from which the pebbles have been derived. A parallel to this may be found in the flattened chalk pebbles on the beach in the Bridlington district. Thus the dominant quartzite pebbles at Budleigh Salterton must have come from a source different from that which has supplied most of those at Cannock Chase.

Reference is also made to a paper of mine on Luxulyanite. It is not easy to disentangle the writer's meaning from the mass of irrelevant matter, but I presume it is not meant to be complimentary, so I may say that though more than a quarter of a century has passed since I wrote this paper, and I have studied many tourmaline-bearing rocks in the interval, I have found no reason to alter the opinion then expressed as to the history and formation of this mineral in that case. I also am familiar with party-coloured crystals of tourmaline, but fail to see that their occurrence affects the accuracy of my original conclusions. I do not remember having

anywhere stated that tourmaline could only be formed in the way which I had described in that particular rock.

Yet more, in regard to the occurrence of magnetite in cubes. With such very minute grains mistakes are more than possible, but I still think that I detect the solid angles of cubes as well as of octahedra, and at any rate submit that this reference to my statement is misleading—"So far as I am aware [this is] the only record of the occurrence of magnetite in cubes in Great Britain"—for I had stated distinctly that the rock which I was describing was not in its natural condition, but, as I said, a basalt which had been completely melted by Messrs. Chance. That fact ought not to have been suppressed. T. G. Bonney.

BRITISH GEOLOGICAL PHOTOGRAPHS.

Sir,—With reference to your most kindly article in the Geological Magazine for September, I should like to be allowed to say a few words, in order to avoid the possibility of misunderstanding.

The published series of "British Geological Photographs" consists of platinotypes (mounted or unmounted) or lantern-slides, accompanied by letterpress, and is issued only to those who undertake to subscribe for the three issues (at least 20 photographs each) of which the publication consists. Sets cannot be broken, and it is not permissible to subscribe for one issue out of the three.

I have room at present for about 20 new subscribers for the three issues, and for 50 new subscribers my Committee would consider the advisability of reissuing the whole series.

The third issue, which I hope to publish within this year, will complete the publication; but the Committee are contemplating the possibility of issuing a supplementary series on the same terms. Such a series would endeavour to fill up gaps in the first series, would illustrate important phenomena a little more fully, and would also include the more uncommon features and phenomena. A certain number of subscribers' names have been received for this supplementary series, but not yet enough to warrant publication. For the descriptions which accompany the photographs and add so much to their value for scientific and teaching purposes, the Committee are indebted to a number of geologists, many of whom are not members of the Geological Photographs Committee. W. W. Watts.

Holmwood, Four Oaks, Sutton Coldfield.
September 7th, 1903.

OBITUARY.

WILLIAM H. CORFIELD, M.A., M.D., F.R.C.P., F.G.S.

Born December 14, 1843. Died August 26, 1903.

We regret to record the death at Marstrand, Sweden, of Professor William Henry Corfield, sanitary adviser to His Majesty's Office of Works, one of our leading authorities on Sanitary Science, and one who brought a sound knowledge of geological science to bear on that subject. He was born in 1843, and was educated at